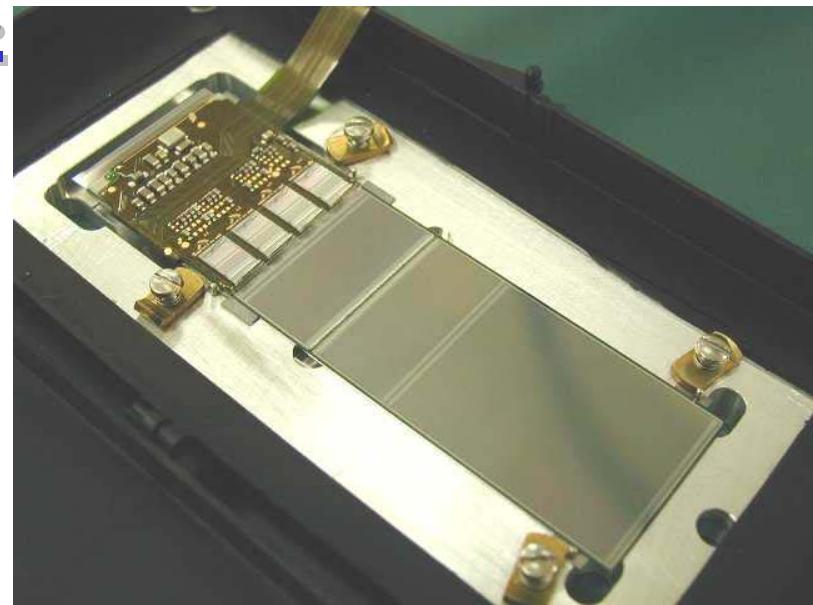
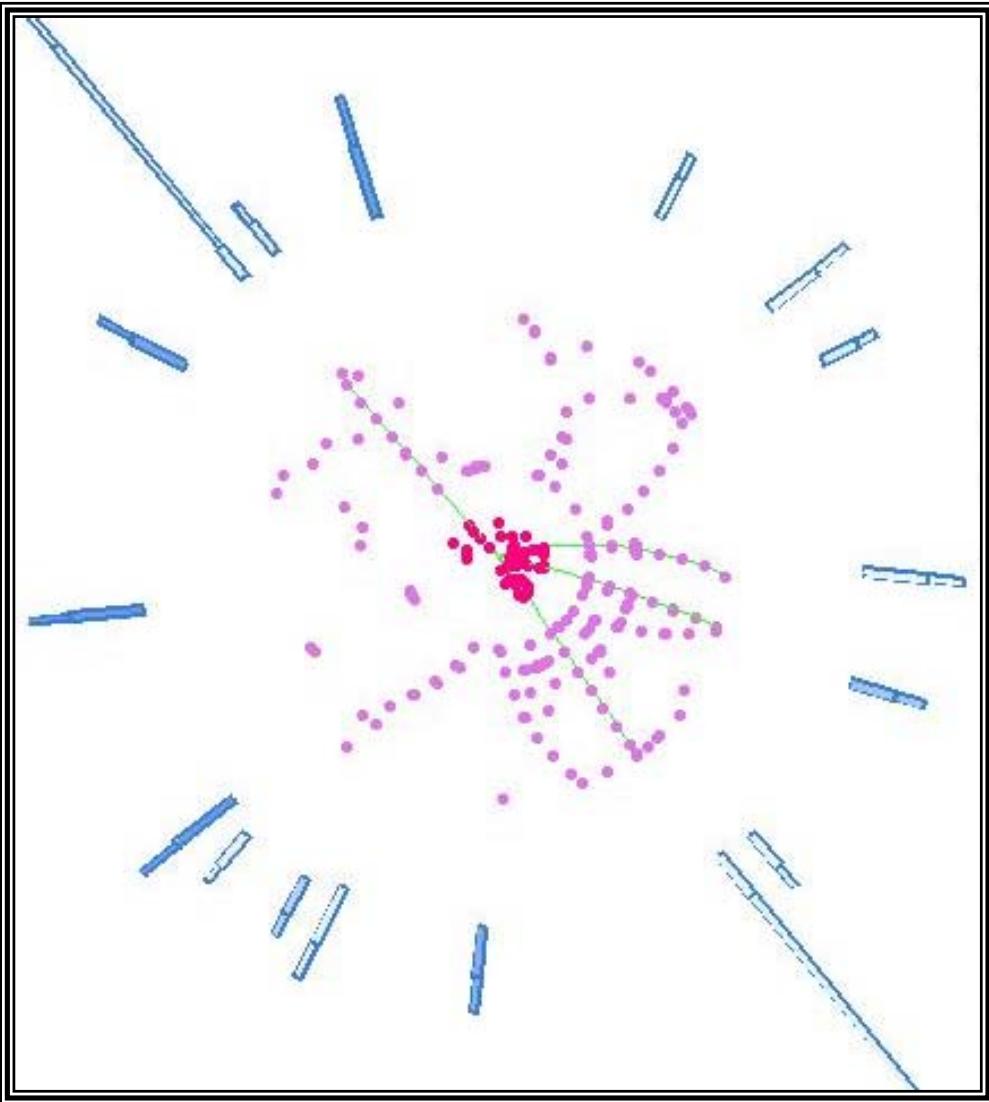
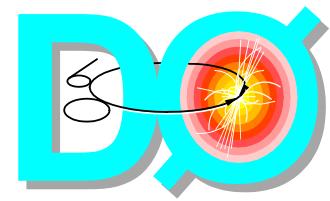
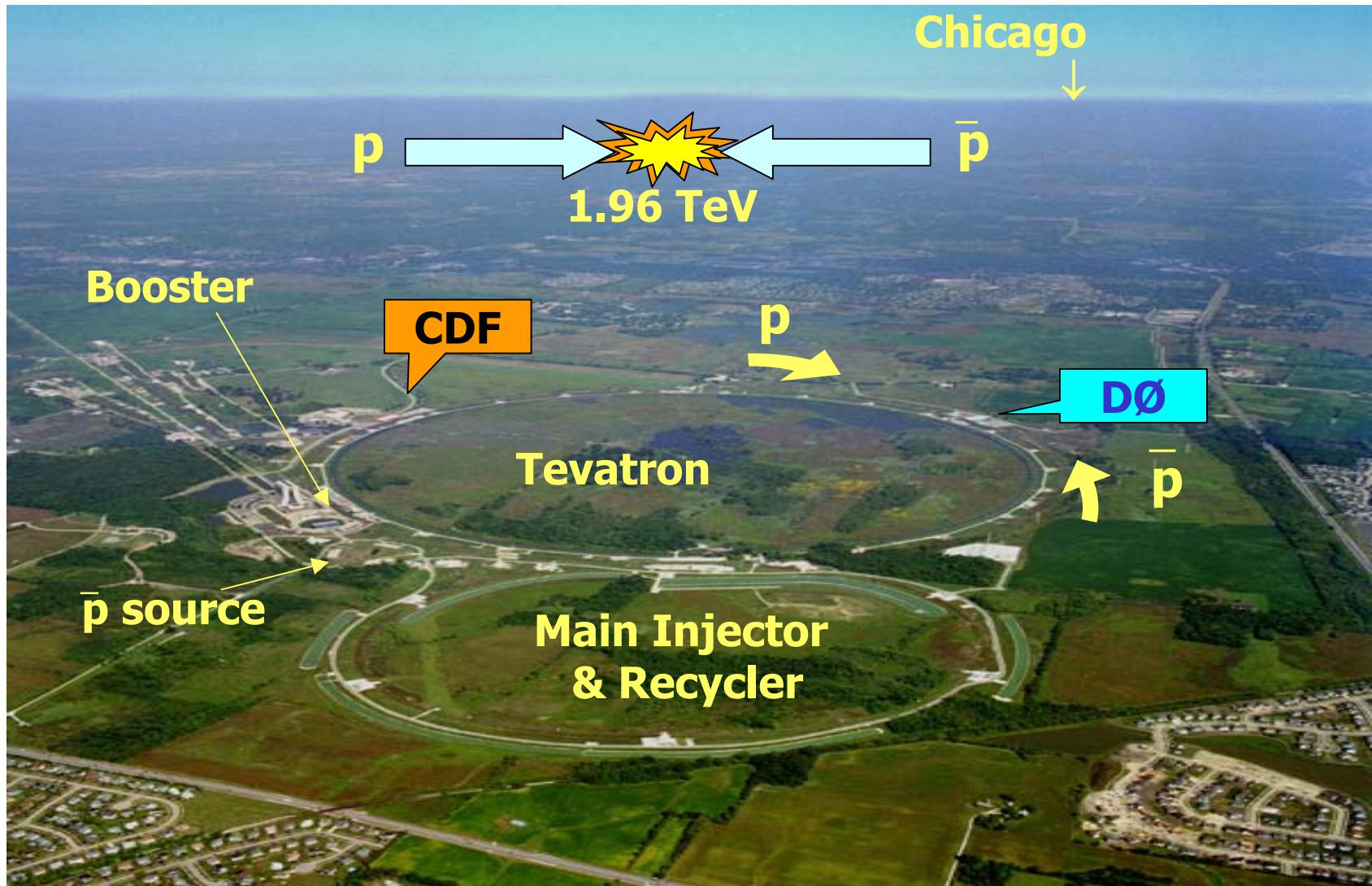


The DØ Tracking System for Run II



George Ginther
University of Rochester
for the DØ Collaboration

The Fermilab Tevatron Collider



An Opportunity

● Explore the energy frontier

- searches

- Higgs boson
- supersymmetry
- extra dimensions
- quark or lepton compositeness,
- new dynamics

- precision measurements of W, Z and top

- B physics

- QCD studies

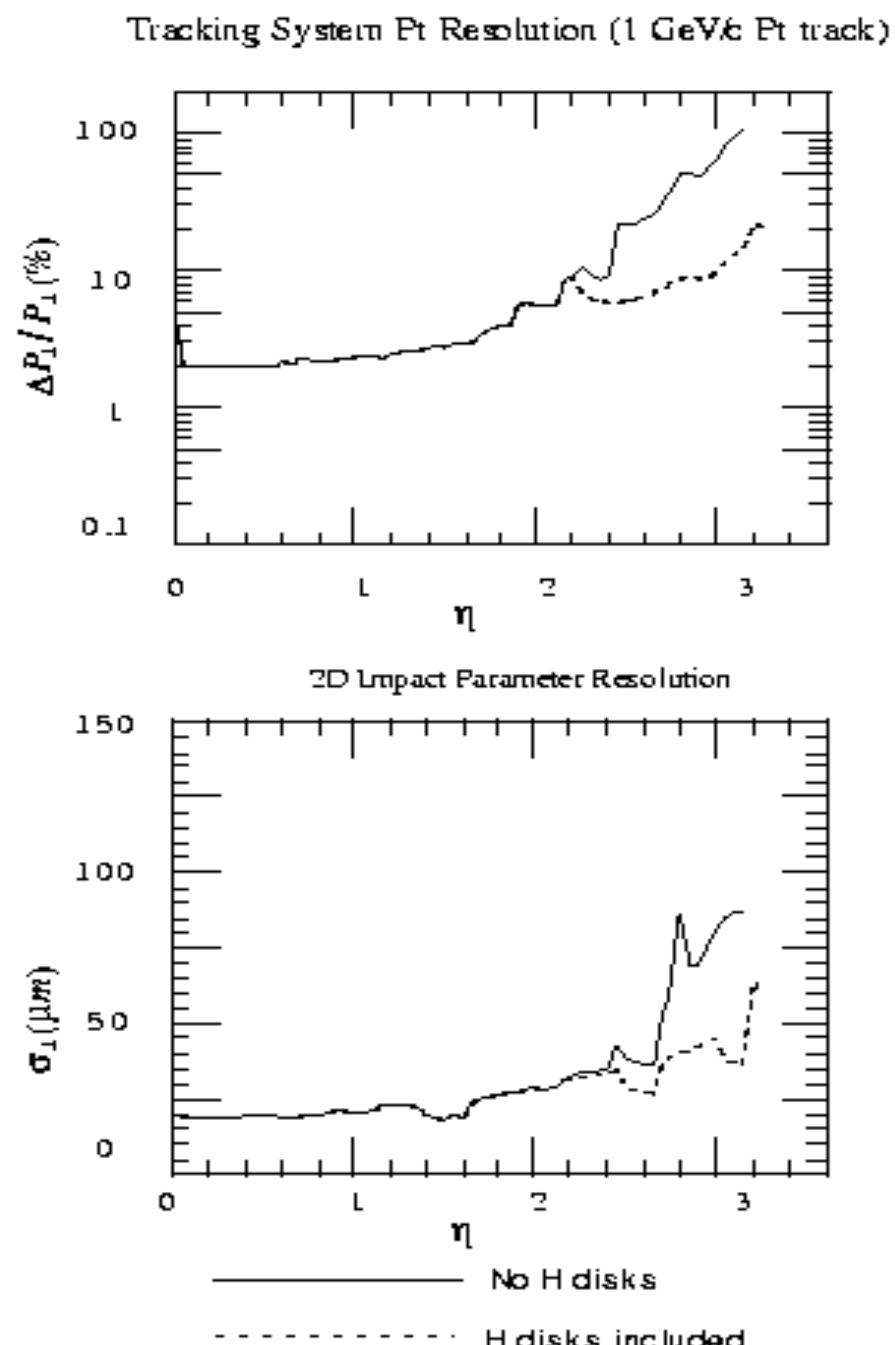
● To take best advantage of this opportunity

- large integrated luminosities (Run IIA $\Rightarrow \sim 2 \text{ fb}^{-1}$)

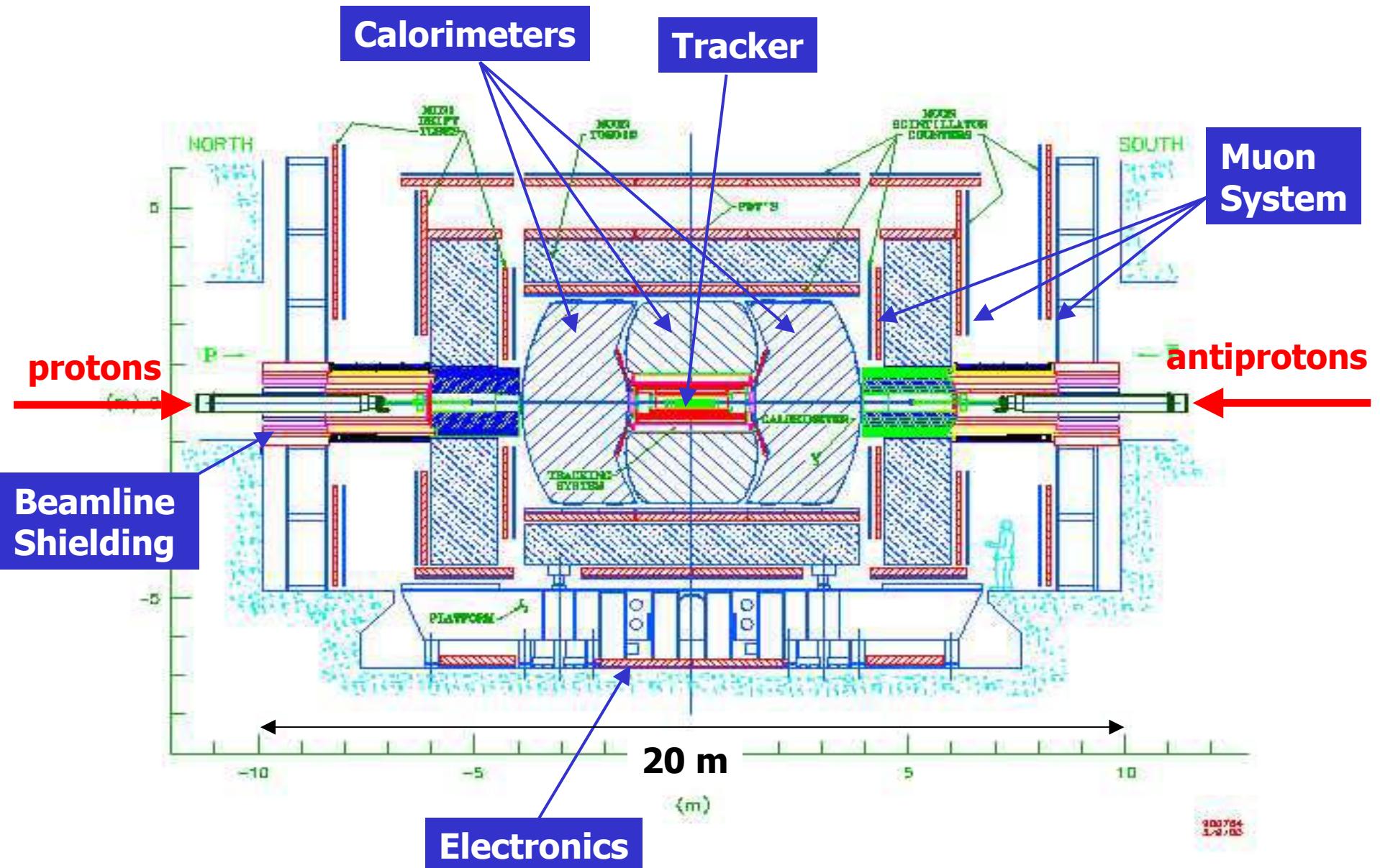
- electron, muon, tau, jet (including b jets) and missing Et measurement capabilities

DØ Tracker Design

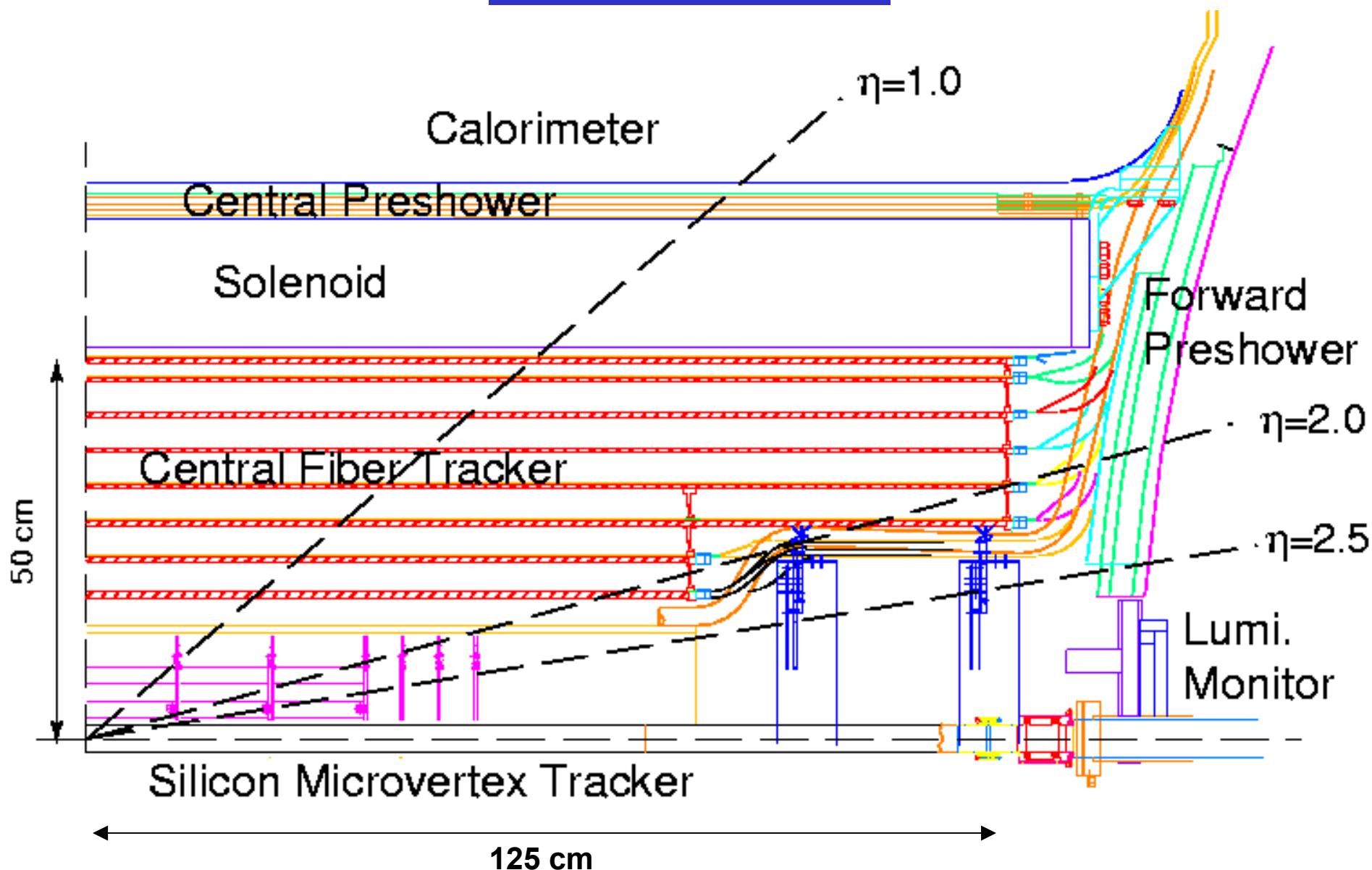
- Tracking system for Run II
 - 2 Tesla superconducting solenoidal magnet
 - Silicon Microstrip Tracker (SMT) and Central Fiber Tracker (CFT)
- Good 3D track reconstruction performance for high- p_T (top, Higgs, EW, NP) and low- p_T (B) tracks out to $|\eta| < 3$
- Momentum resolution $\approx 2\%$ at $p_T = 1 \text{ GeV}/c$ for $|\eta| < 1$
- Impact parameter resolution within $30 \mu\text{m}$
 - SMT H disks are employed to achieve these resolutions at high $|\eta|$



The Run II DØ Detector

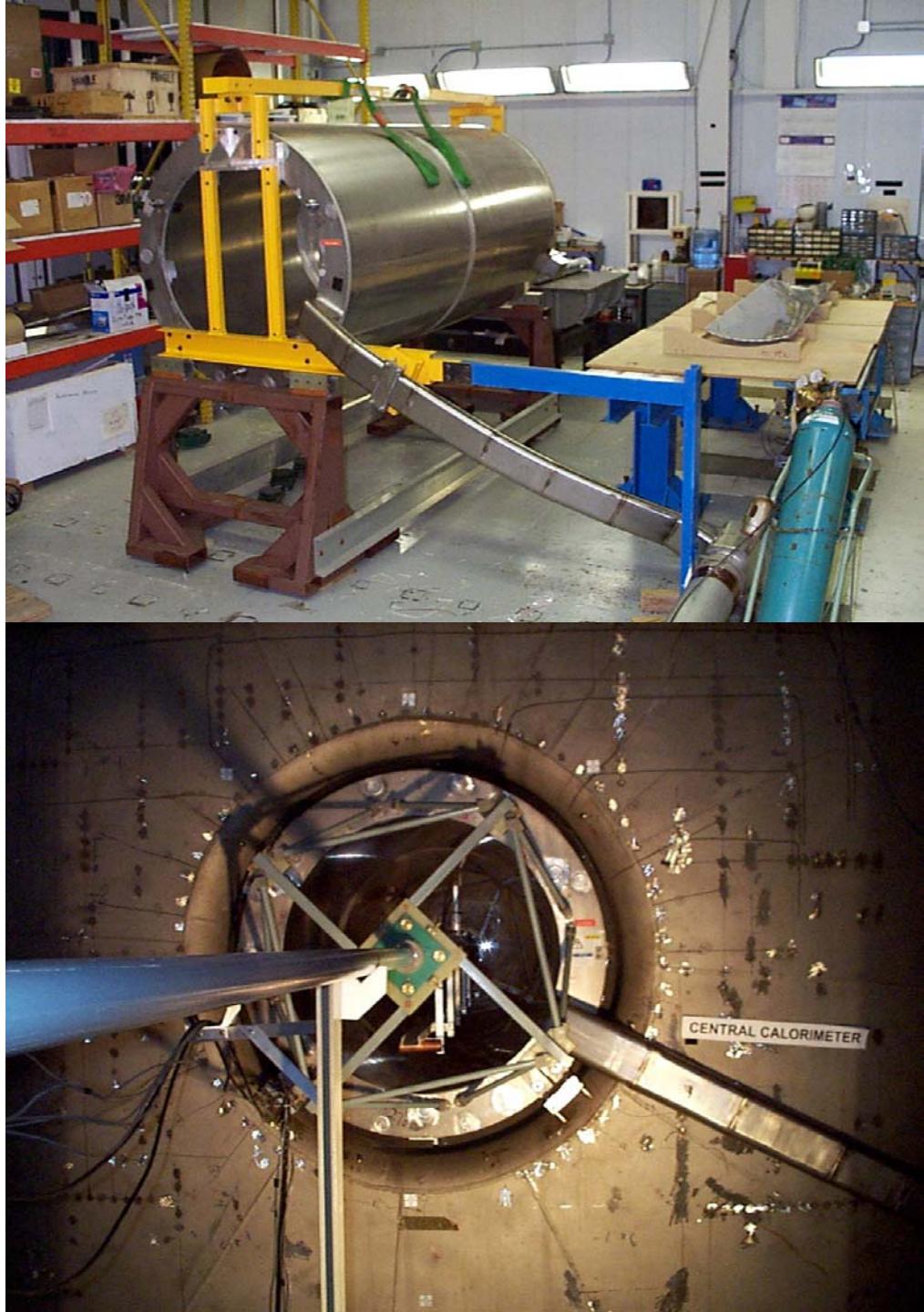


DØ Tracker

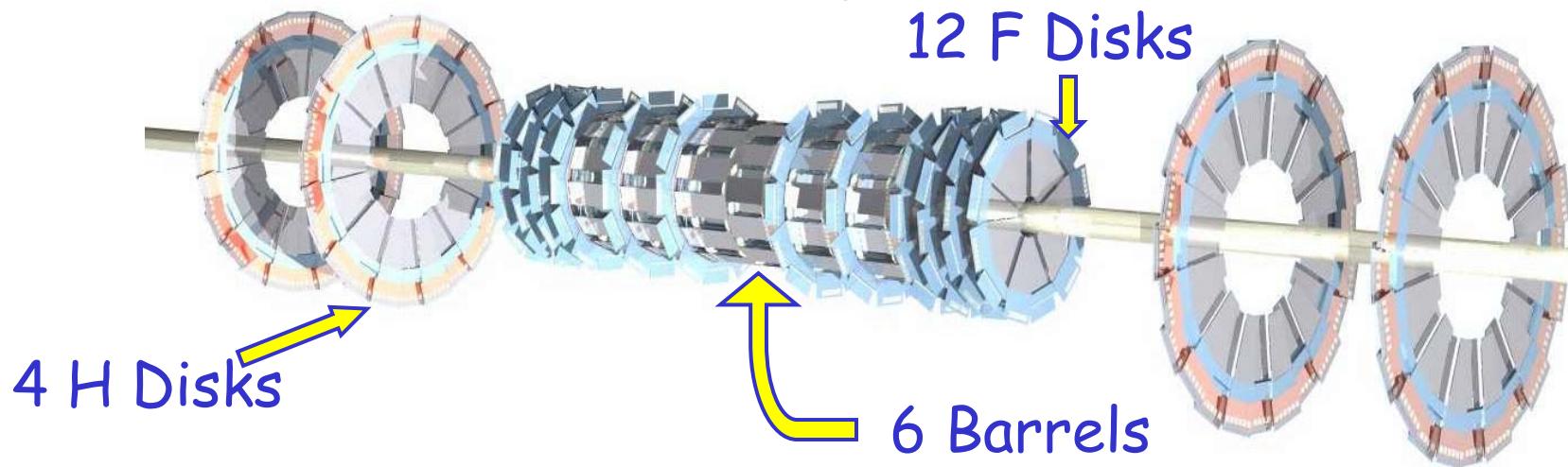


Solenoid

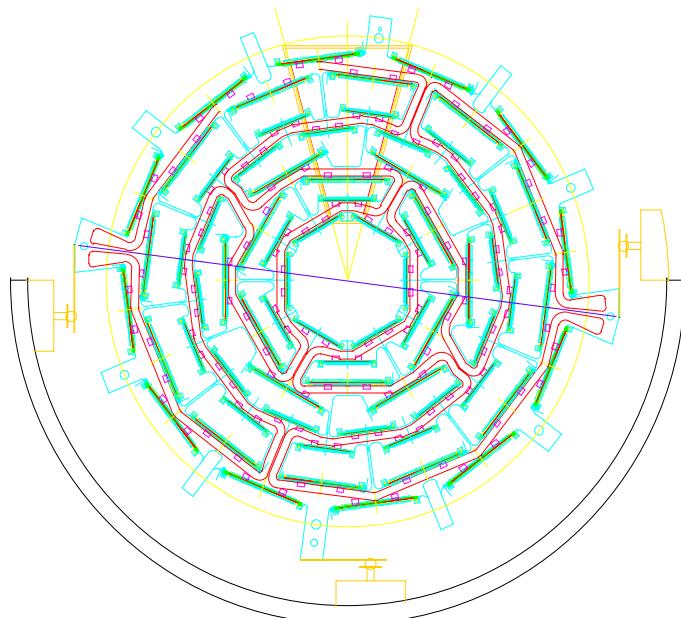
- 2.7 m long 2 Tesla field
- 5 MJ stored energy
- Two layer superconducting coil with mean radius of 60 cm
- $\sin\theta \int B_z dl$ is uniform to within 0.5%
 - achieved using two grades of conductors with higher densities near ends of coils
- Coil and cryostat ≈ 0.9 rad lengths
- Manufactured by Toshiba Corporation
- Delivered May 97



Silicon Microstrip Tracker (SMT)



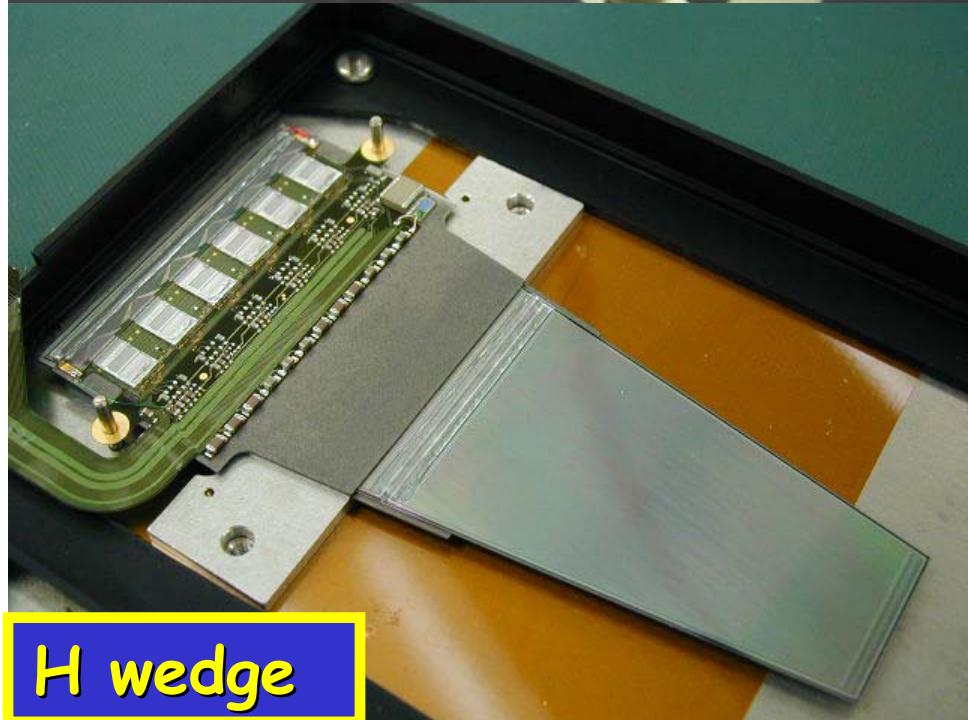
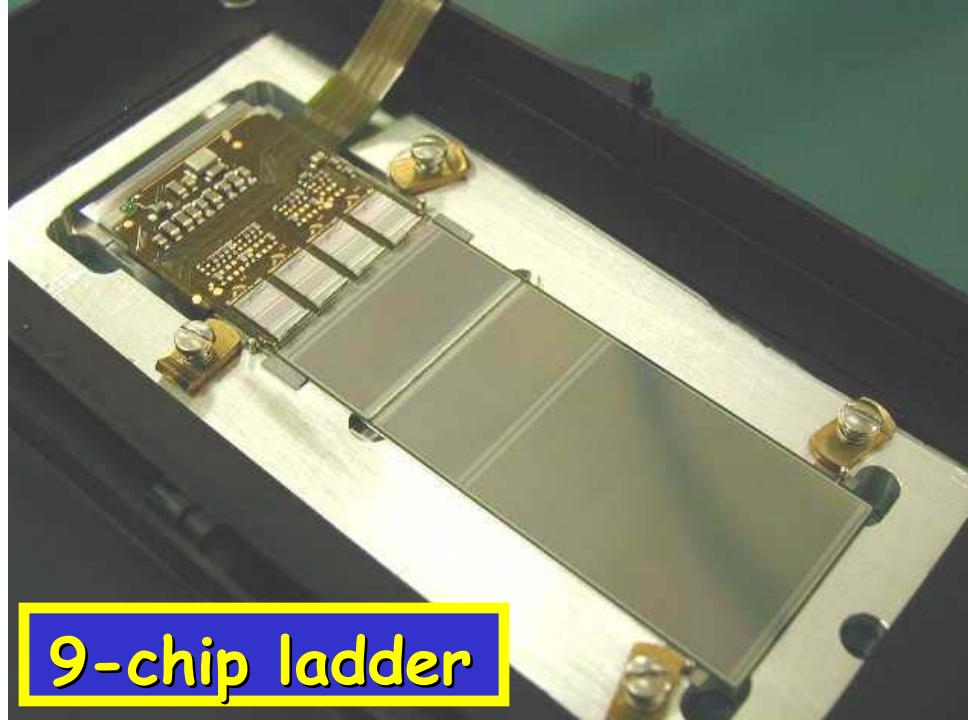
4-layer barrel cross-section



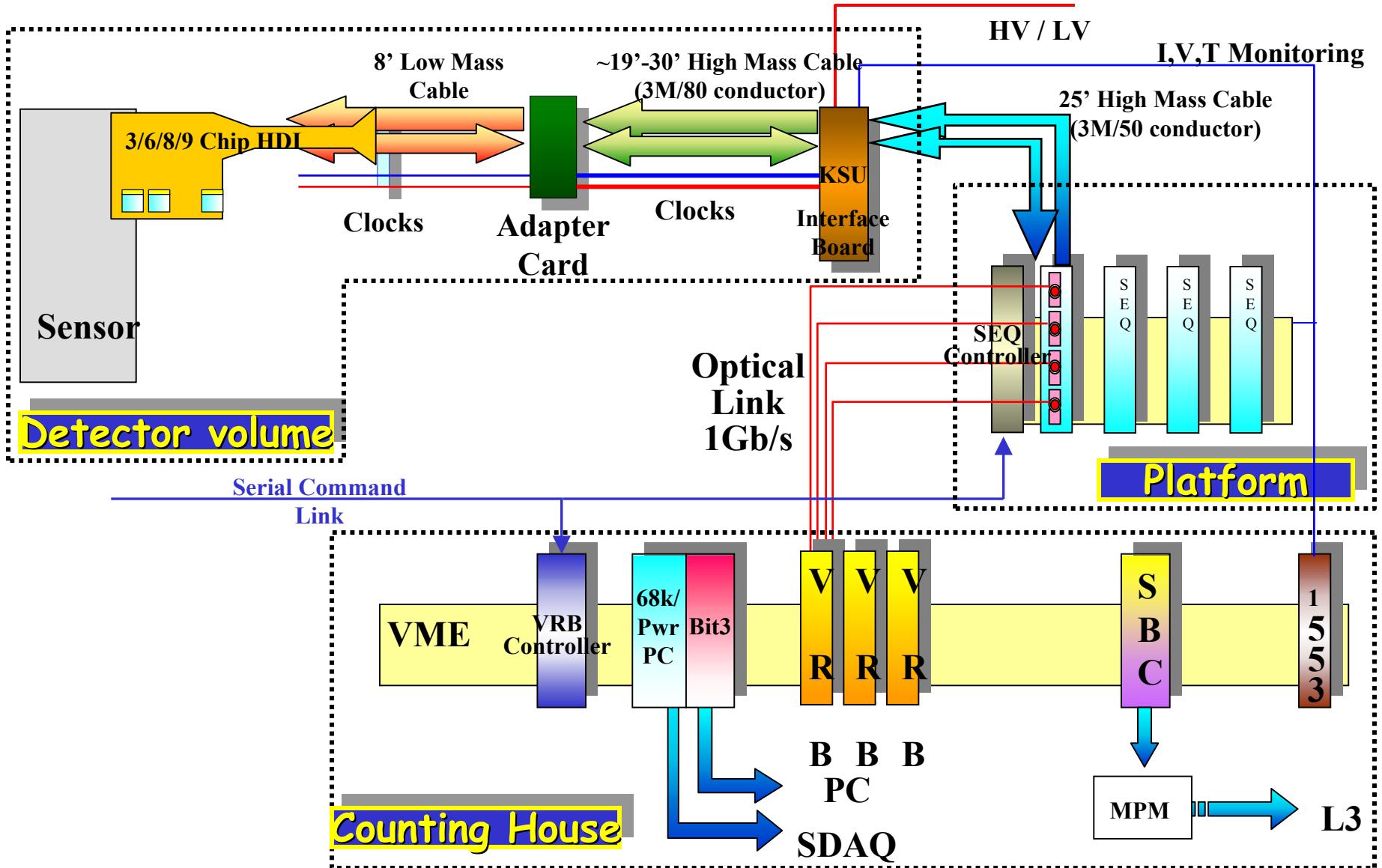
	Barrels	F-Disks	H-Disks
Stereo	sngl + dbl	double	single
Channels	0, 2, 90	+/-15	+/-7.5
Modules	387072	258048	147456
Inner R	432	144	96
Outer R	2.7 cm	2.6 cm	9.5 cm
	9.4 cm	10.5 cm	26 cm

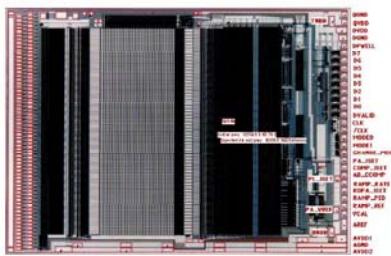
SMT

- 793K channels
- 3 m² of silicon
- >2.3 million wirebonds
- Ladders
 - 3-chip: 72 single-sided, axial ladders in the two outer barrels
 - 6-chip: 144 double-sided, axial/90° ladders in the four inner barrels
 - 9-chip: 216 double-sided, axial/2° ladders in all barrels
 - Mechanical accuracy of 2 to 5 μm
- Wedges
 - F Disks: 144 double-sided, ±15°, 6+8 chip wedges
 - H Disks: 96×2 back-to-back single-sided, ±7.5°, 6 chip wedges
 - Mechanical accuracy of 5 to 10 μm
- CMM aligned ladders and wedges to better than 20 μm



SMT Readout: Data Flow





SMT Readout Electronics

● Interface Boards

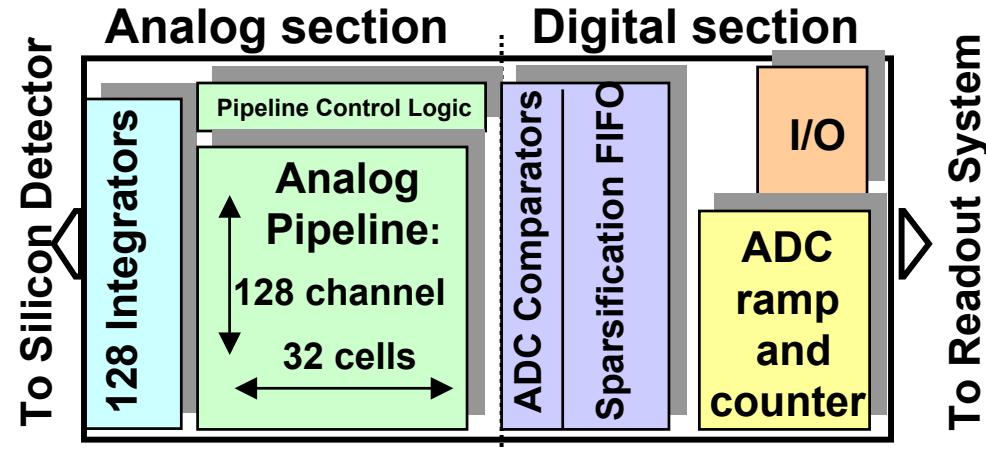
- Refresh signals and adjust timing
- Power management and monitoring

● SEQencers

- Management of SVX
- Fiber optic output

● VME Readout Buffer

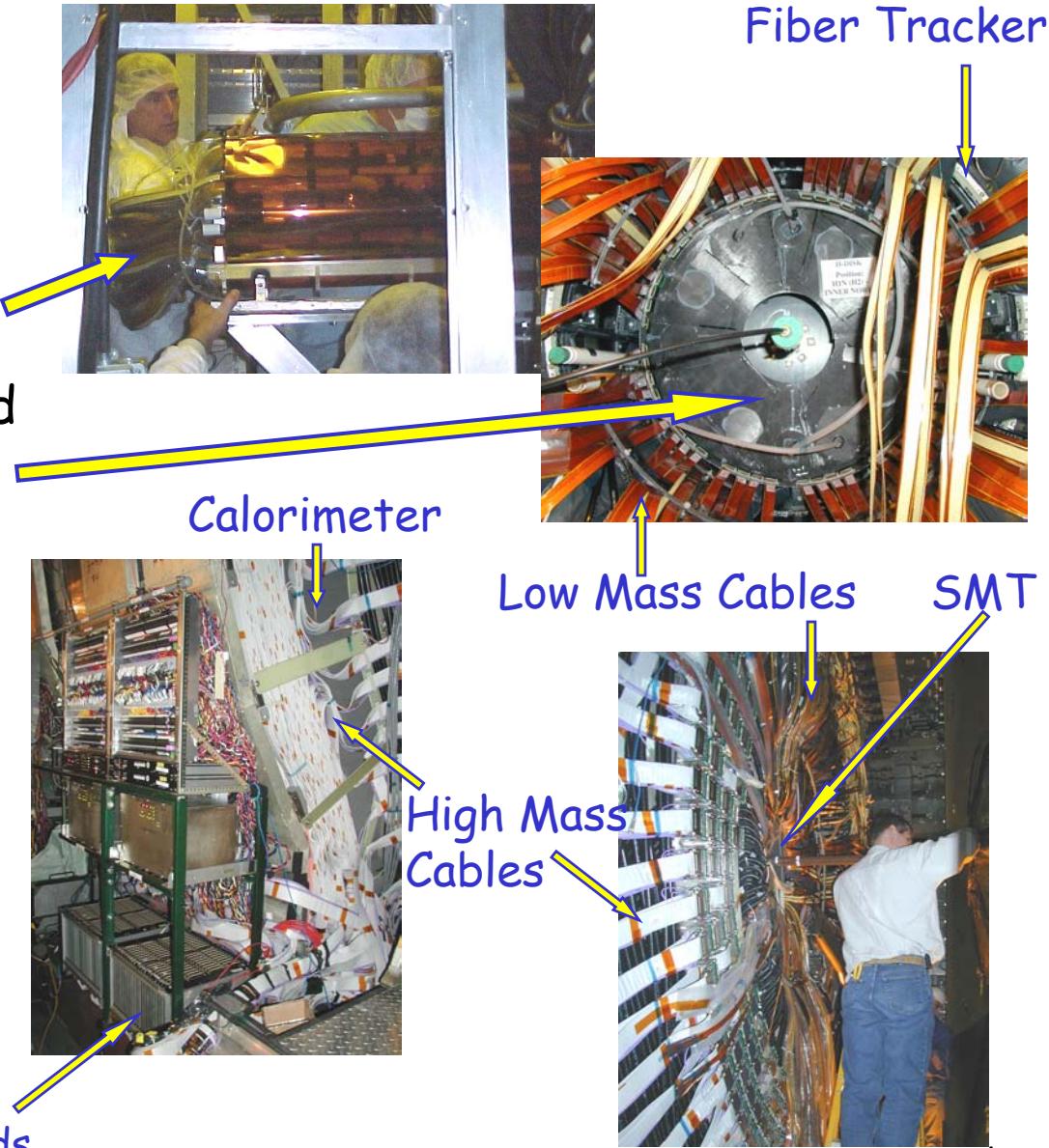
- Data buffer pending L2 trigger decision
- ~ 50 Mb/s/channel
- 10 kHz L1 accept
- 1 kHz L2 accept rate





SMT Installation

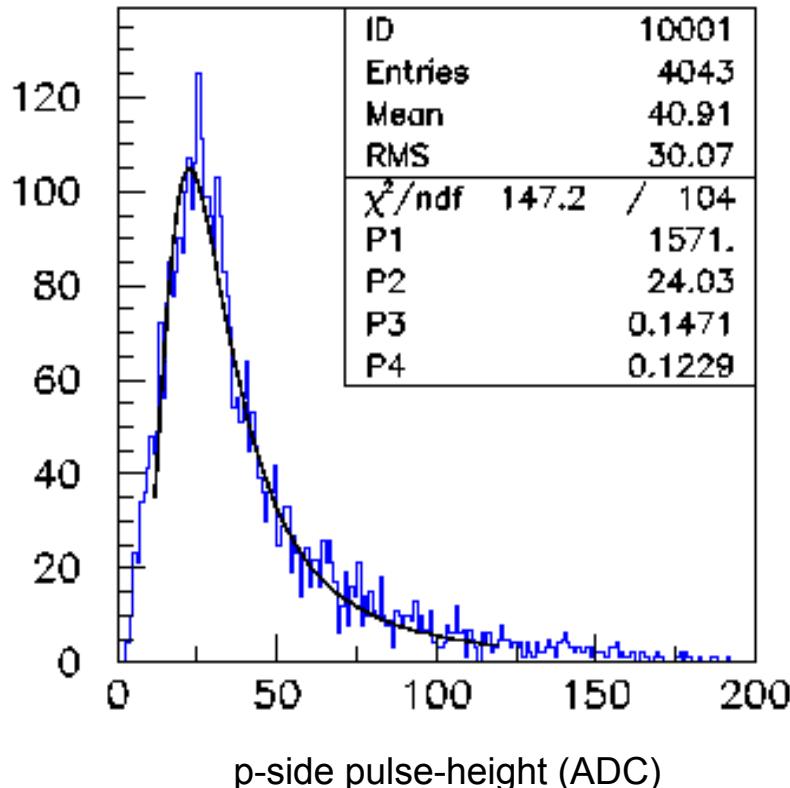
- Cylinder installation was completed Dec 2000
 - A $\frac{1}{2}$ cylinder of 3 barrels and 6 F disks was inserted into each end of the CFT bore
- H Disk installation was completed Feb 2001
- The cabling (~15,000 connections) and electronics installation was completed in May 2001



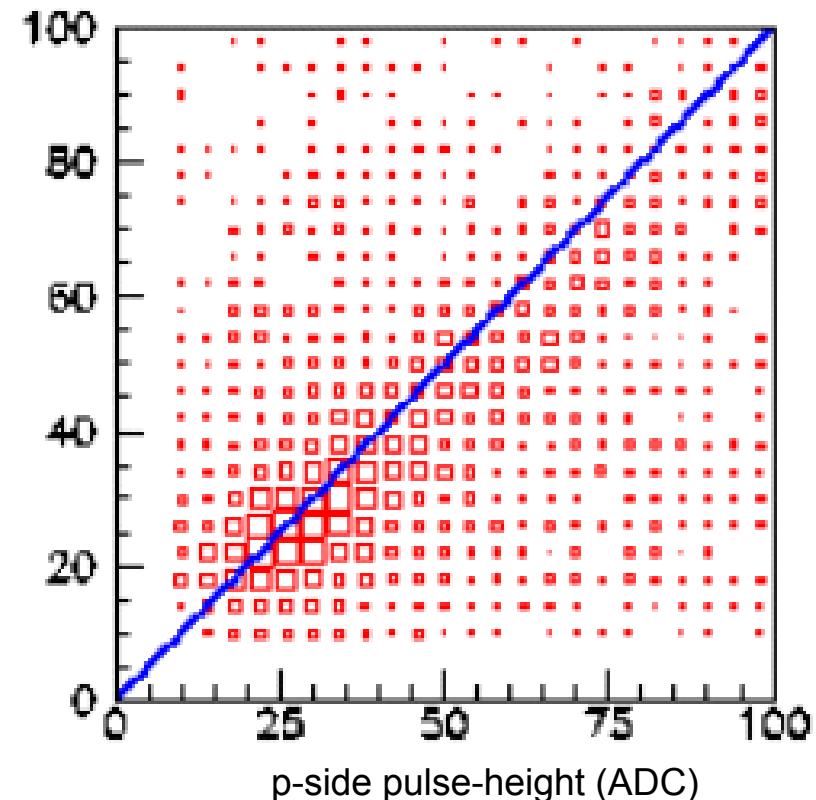
SMT Charge Collection

- Cluster charge
(corrected for track angle):

- 1 mip $\Rightarrow \sim 4\text{fC} \Rightarrow 25 \text{ ADC counts}$
- Noise $< 2 \text{ ADC counts}$

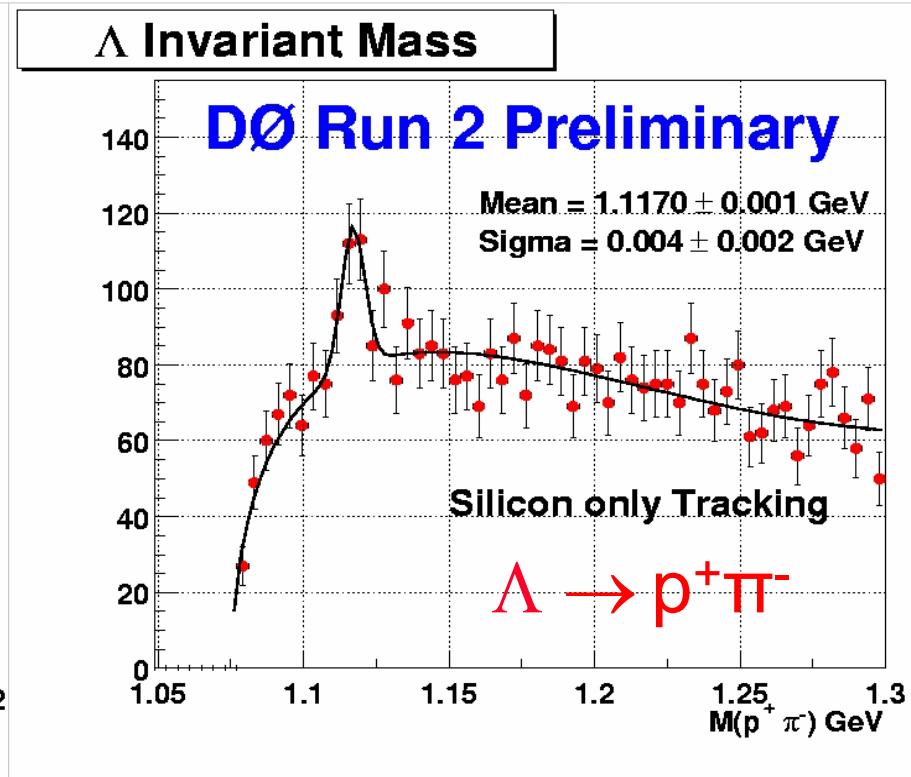
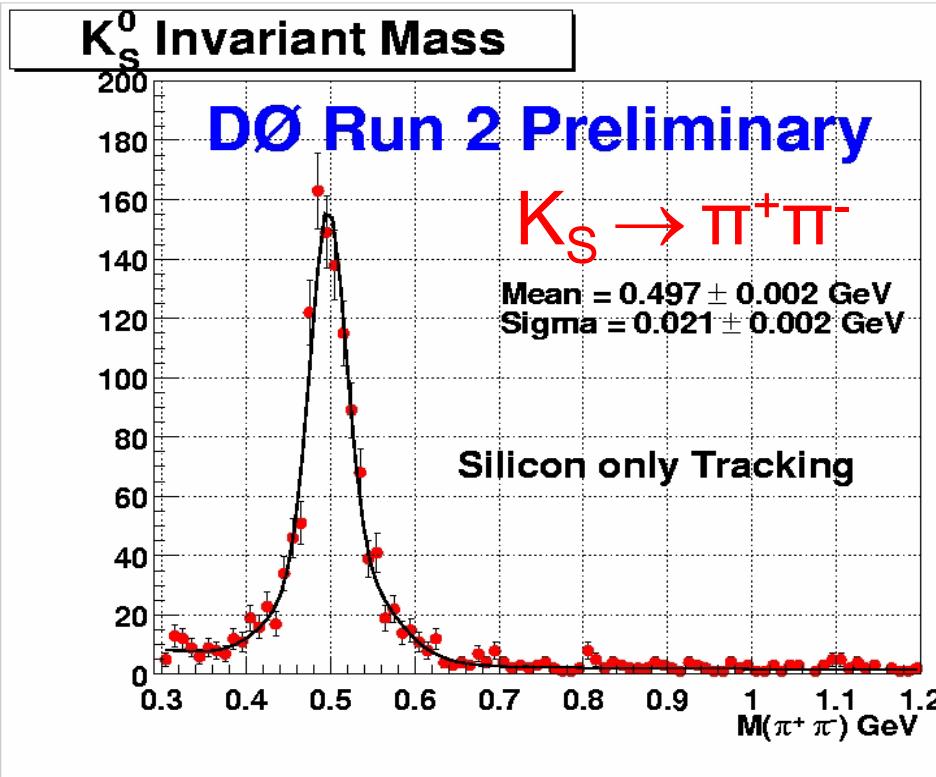


- Charge correlation
between p- and n-side
of a detector



SMT Results

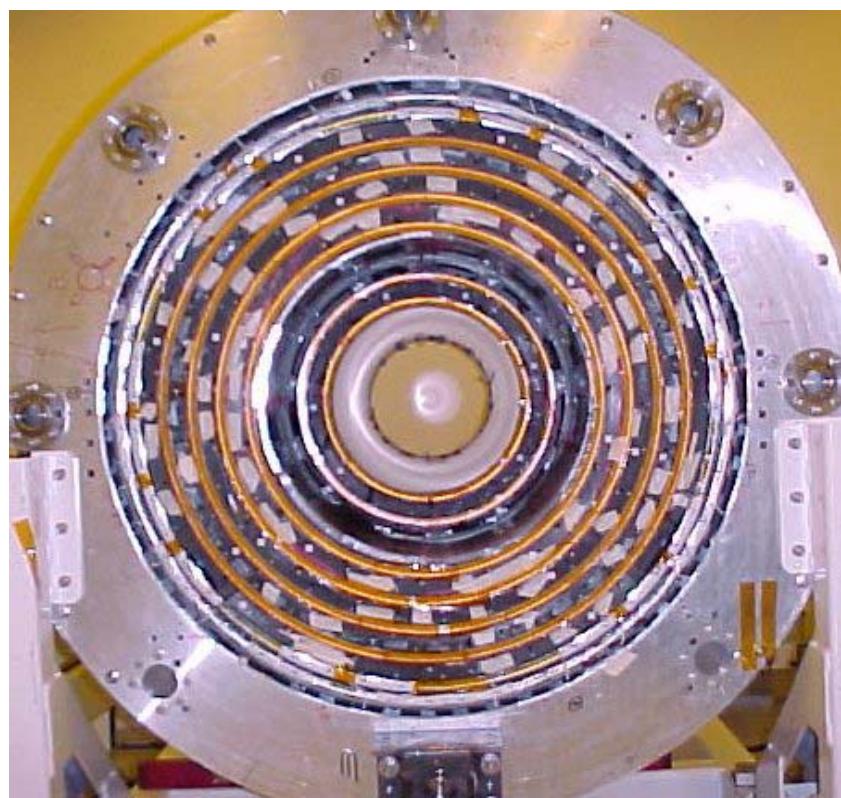
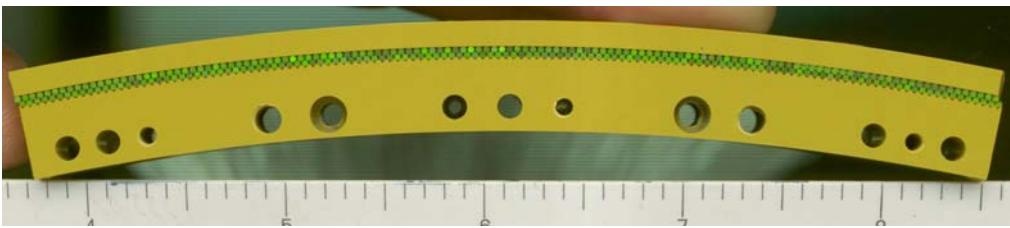
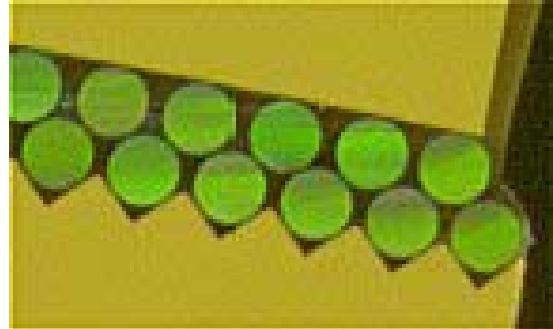
- $\approx 95\%$ of SMT channels available for readout
- Hit efficiencies for good single silicon detectors $> 97\%$
- Explicit V^0 reconstruction using SMT only tracks



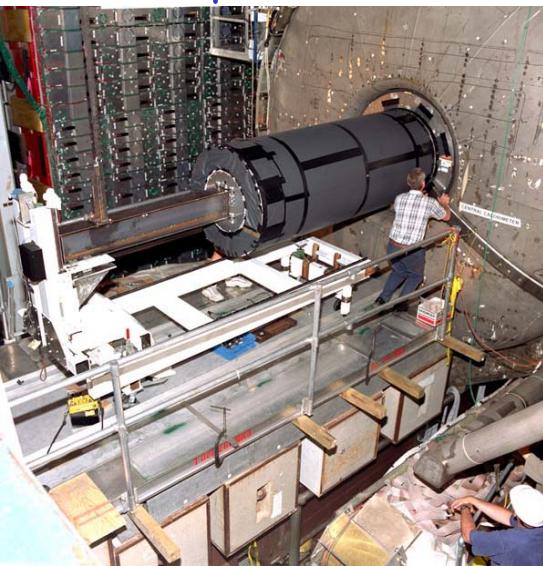
clustering to improve resolutions, and performance

Central Fiber Tracker (CFT)

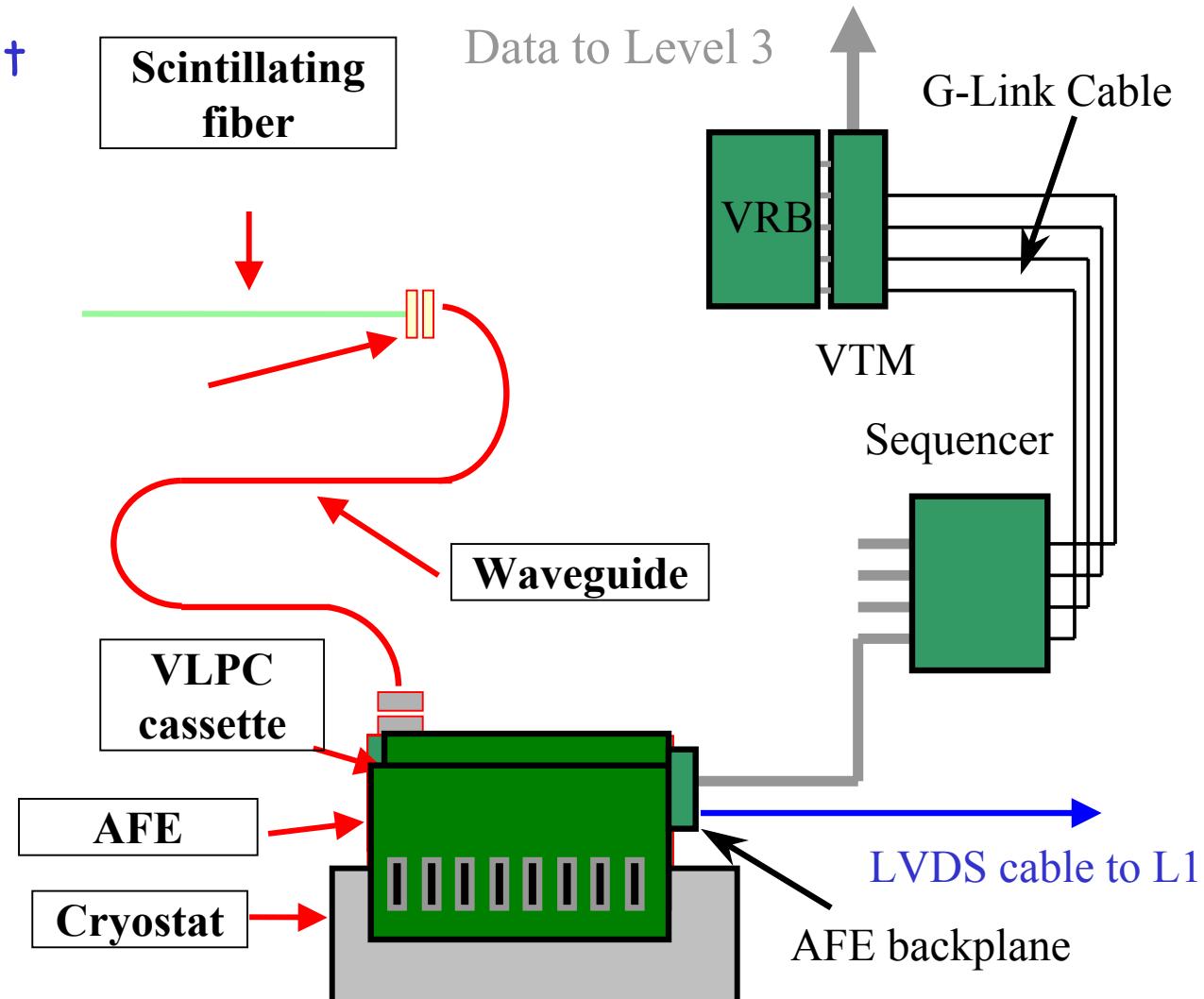
- 835 μm diameter multi-clad scintillating fibers arranged into precisely positioned ribbons of interlocked fiber doublets
- 256 fibers per ribbon
- Pairs of ribbons mounted on outside surface of eight carbon fiber support cylinders
- Inner ribbons on each cylinder have fibers oriented along the cylinder axis (axial view)
- Outer ribbons on each cylinder have fibers oriented at $\pm 3^\circ$ angle (stereo view)
- Scintillating fibers on outer six cylinders are 2.5 m long



- Total of 76800 scintillating fibers
- Bundles of 8.2 to 11.4 m long clear fibers (waveguides) pipe light to individual light sensitive detectors (Visible Light Photon Counter pixels)
- \approx 10 photons to VLPCs
- Position resolution of fiber doublet is $\approx 100\mu\text{m}$



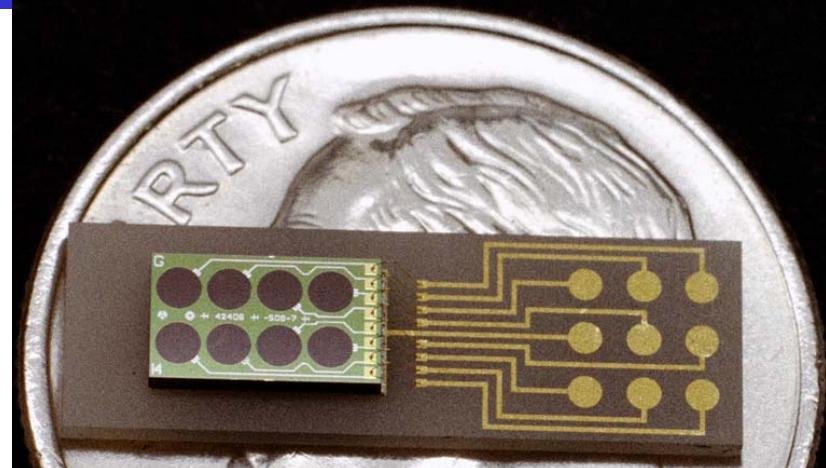
CFT Readout



Visible Light Photon Counters (VLPC)

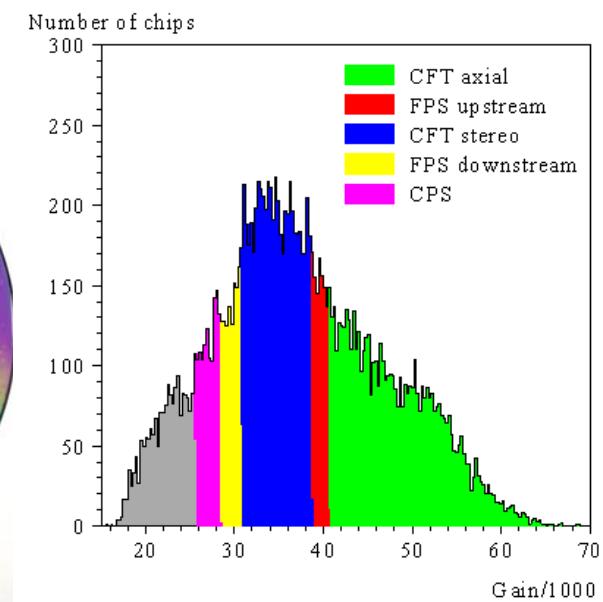
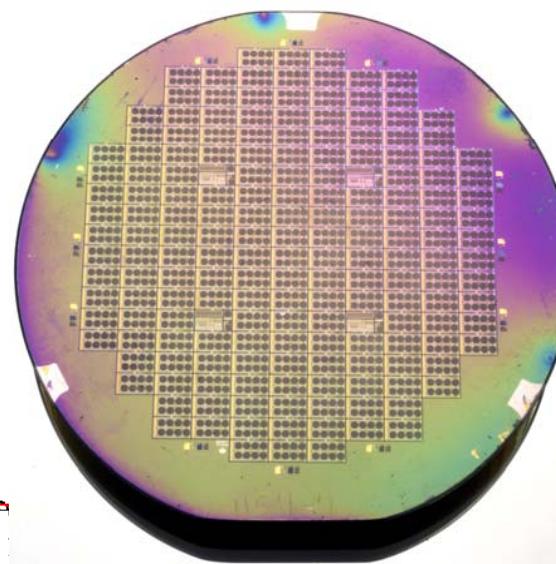
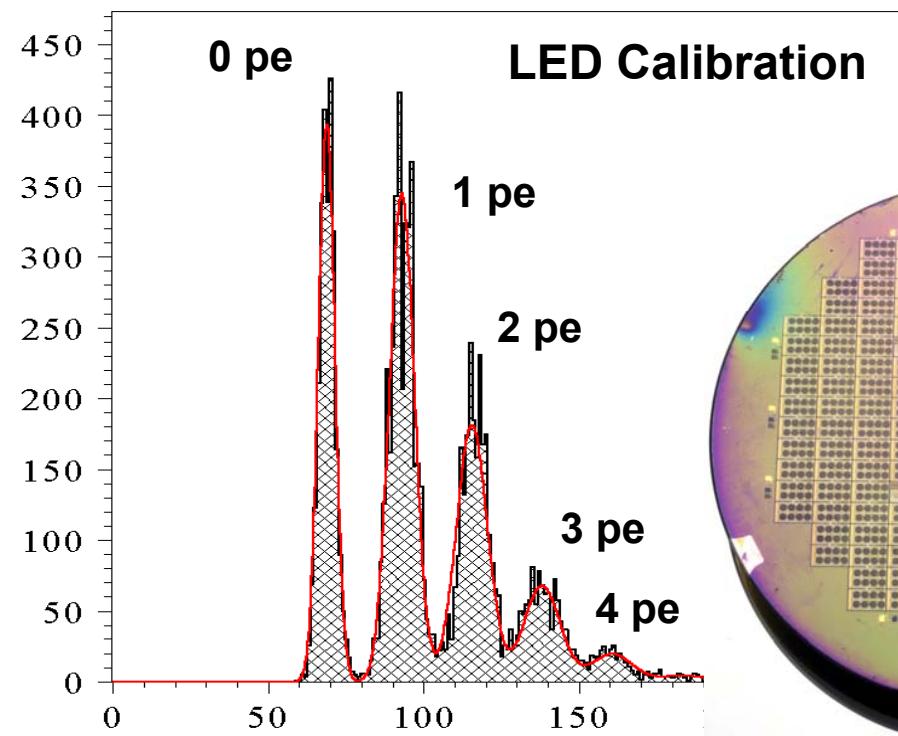
- solid state photo-detectors

- 1 mm diameter pixels arranged in 2x4 array
- function at high rates
- quantum efficiency $\approx 80\%$
- low gain dispersion
- operated at $9K \pm 0.05K$



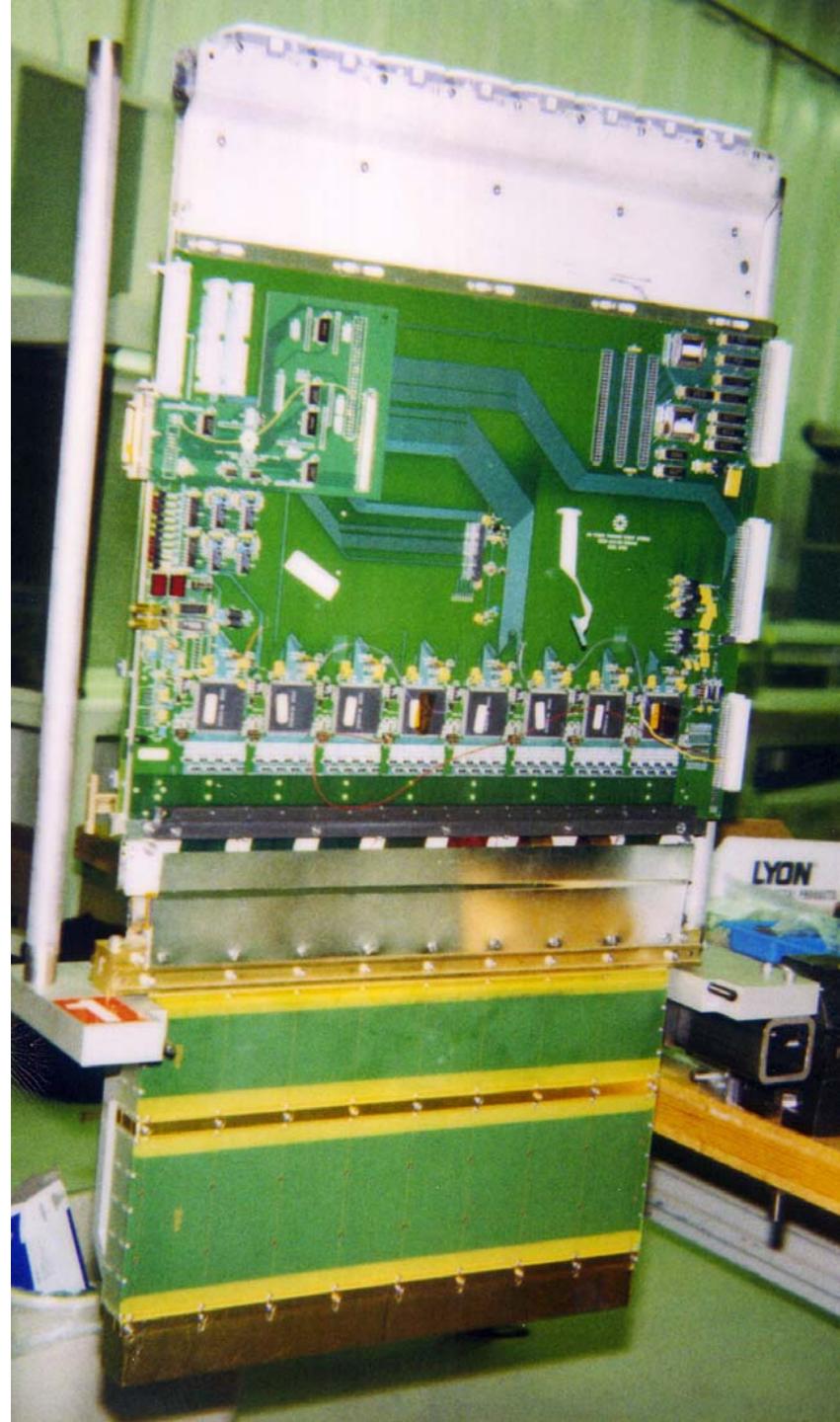
- VLPC fabricated in wafers of 176 chips

- gain, optimal bias voltage, relative QE, and rate effects vary among and across wafers

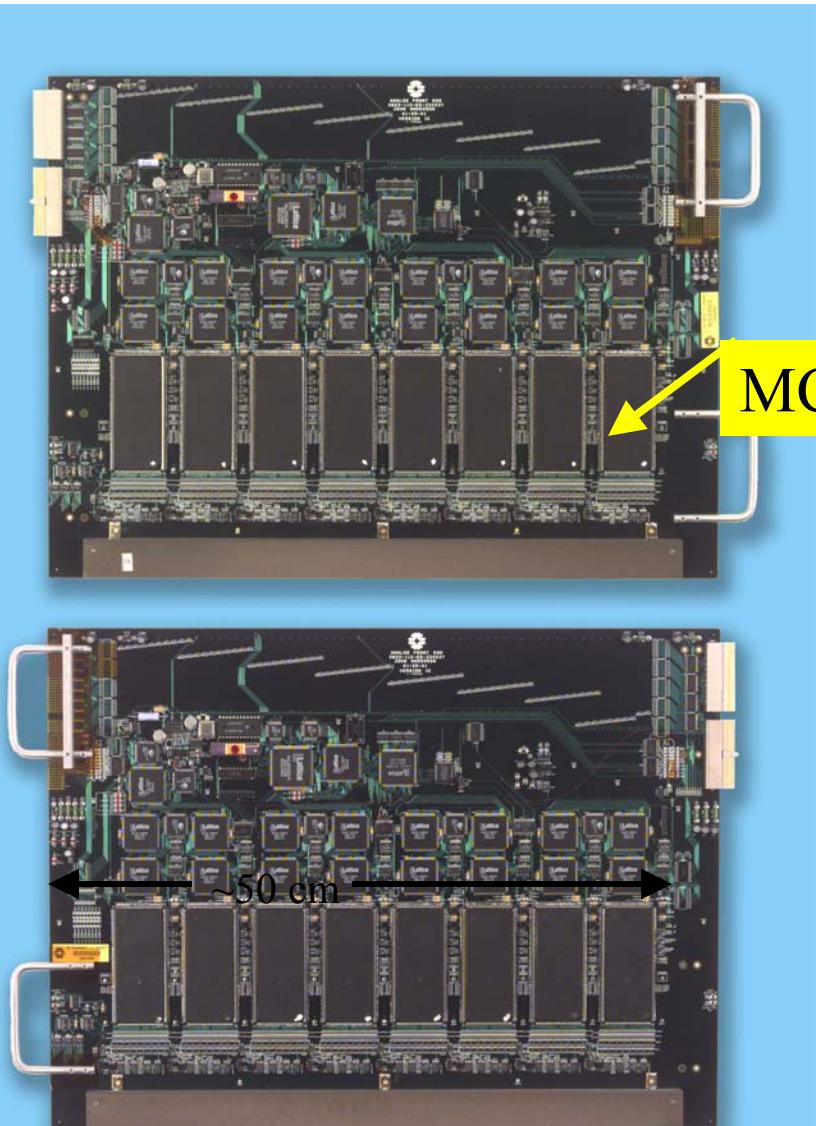


VLPC Cassette

- VLPC performance is sensitive to the operating temperature, bias voltage, and the background rate
- Optimize VLPC performance by grouping chips which exhibit similar characteristics
- Cassettes provide mechanical support, optical alignment, and appropriate operating services for proper operation and readout of the VLPCs
- 1024 channels of VLPC readout per cassette organized into eight independent modules of 128 channels
- Lower portion immersed in gas Helium
- Upper portion supports printed circuit board for trigger and readout



Analog Front End Boards (AFE)



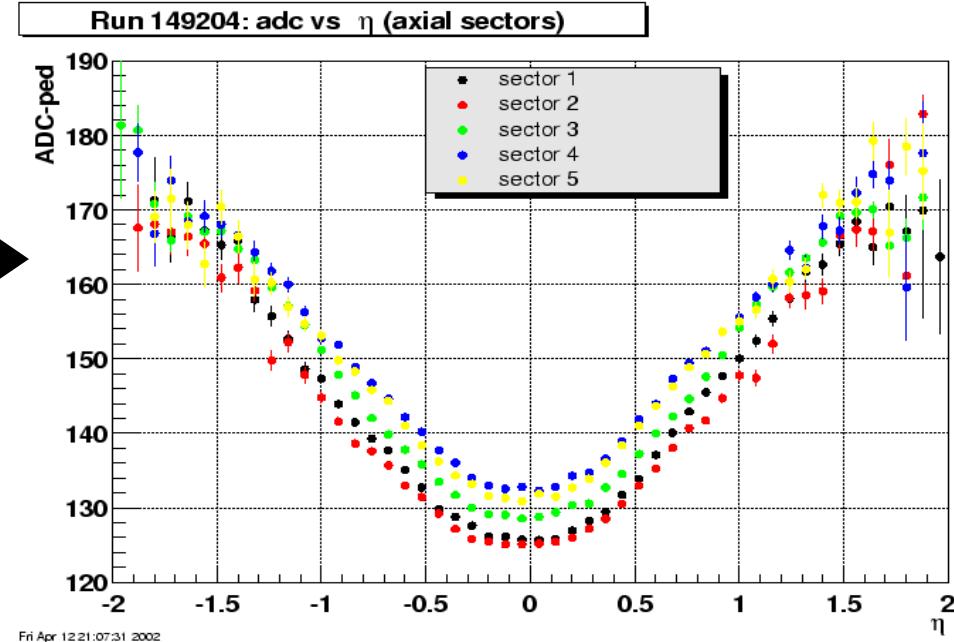
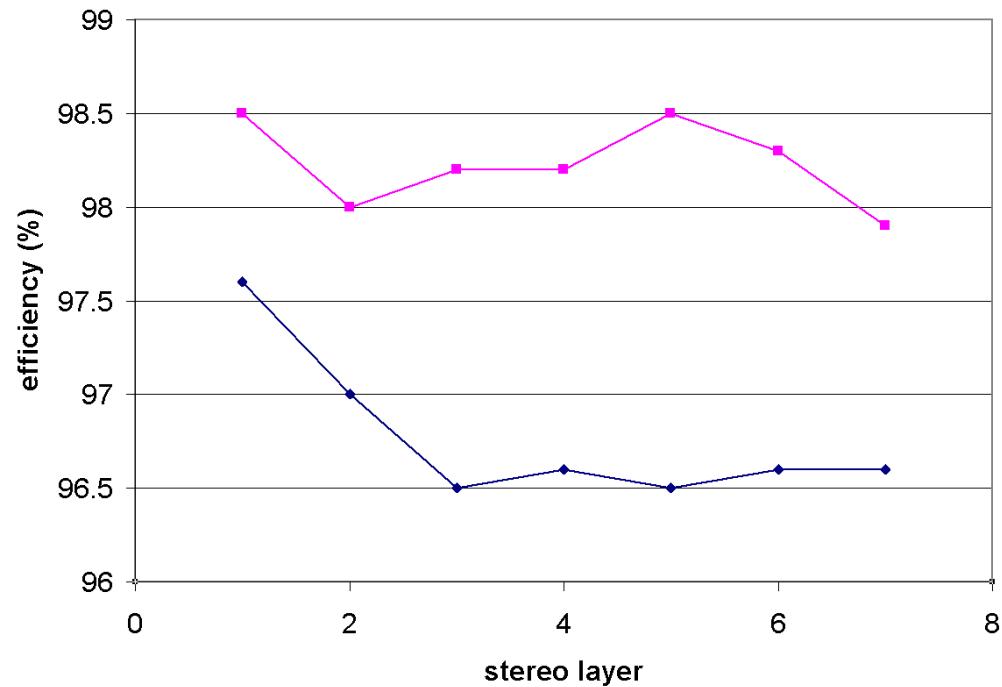
- 512 channels per AFE board
 - ~8 photoelectrons per MIP → ~50 fC signal
 - SVX IIe chip for pulse height information
 - discriminated output for trigger
 - VLPC temperature control and monitoring
 - 9K with $\pm 0.050\text{K}$ precision
 - VLPC bias voltage control and monitoring
 - 6 to 8 V with $\pm 0.050\text{V}$ precision
- AFE boards controlled by SEQuencers and data is readout to VRBs (similar to SMT readout)
- CFT axial fully instrumented by Jan 2002
- CFT stereo fully instrumented by April 2002

CFT Performance

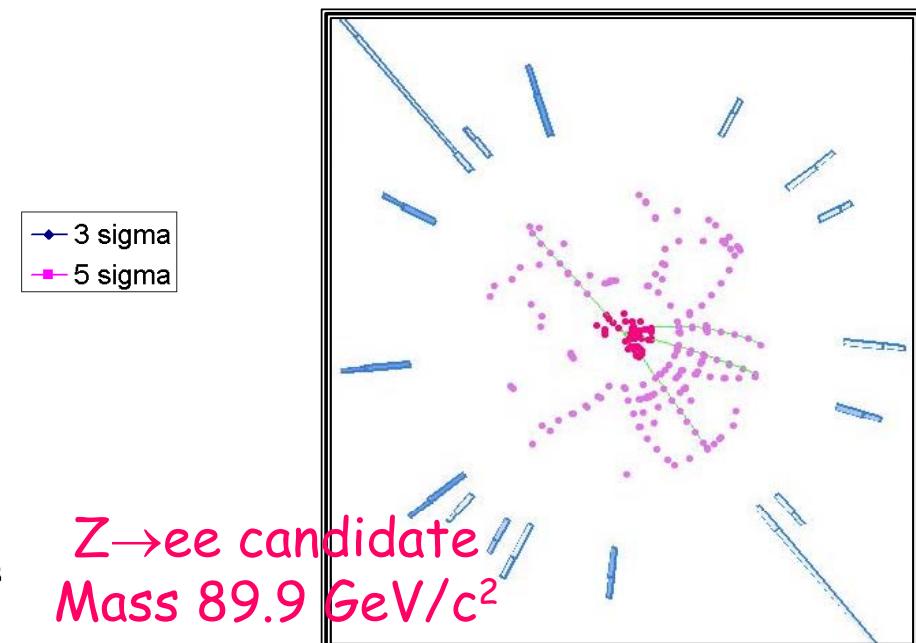
- Light yield depends upon path length through scintillator
- Using good 15 hit CFT tracks, the probability of a cluster within a 3σ or 5σ search window of track in excluded layer is better than 96.5% or 98% respectively

Chart Area

Single track hit efficiencies

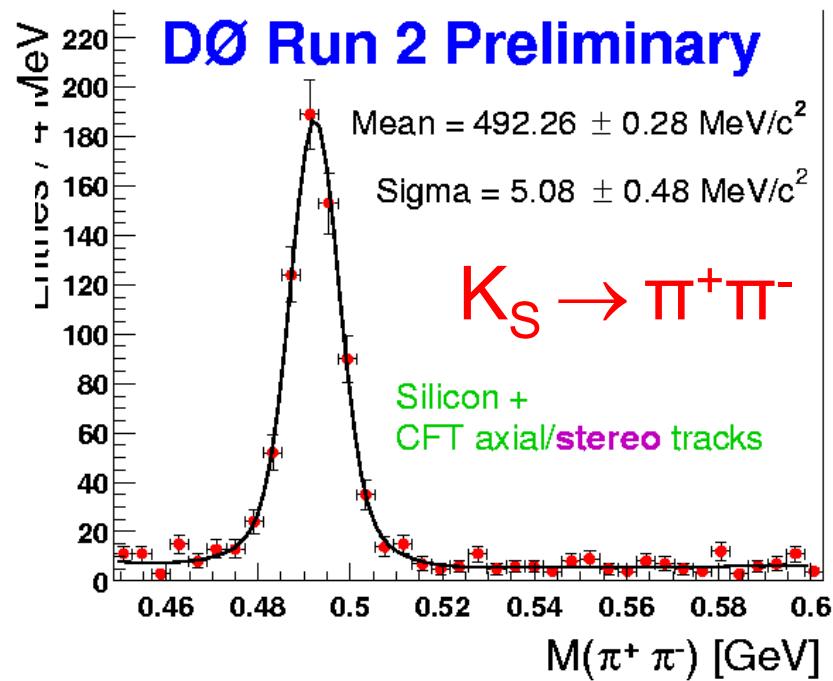
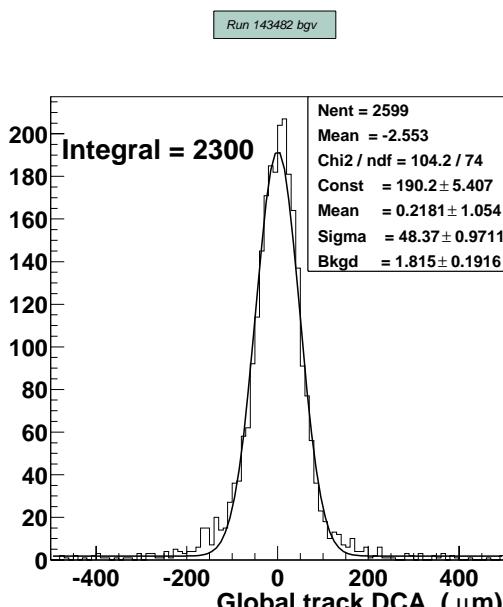
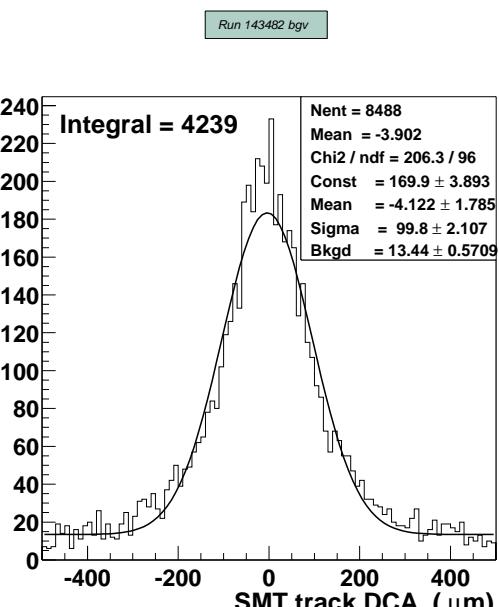
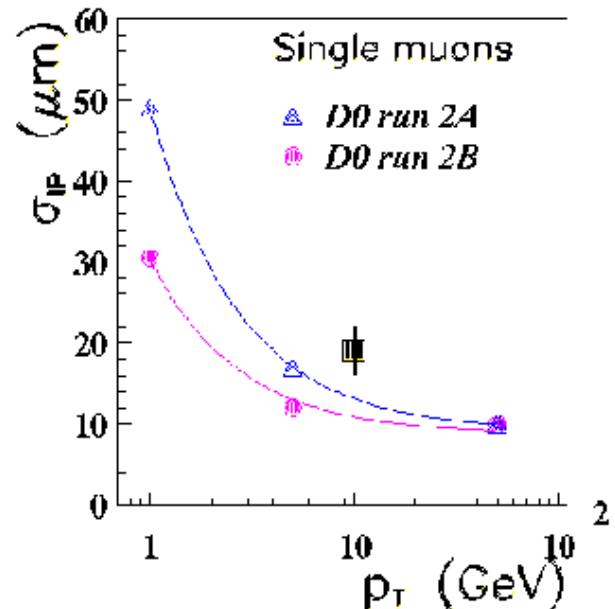
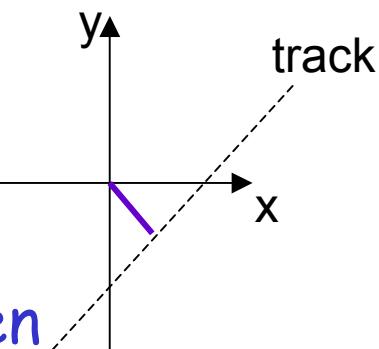


Mean light yield as a function of pseudorapidity

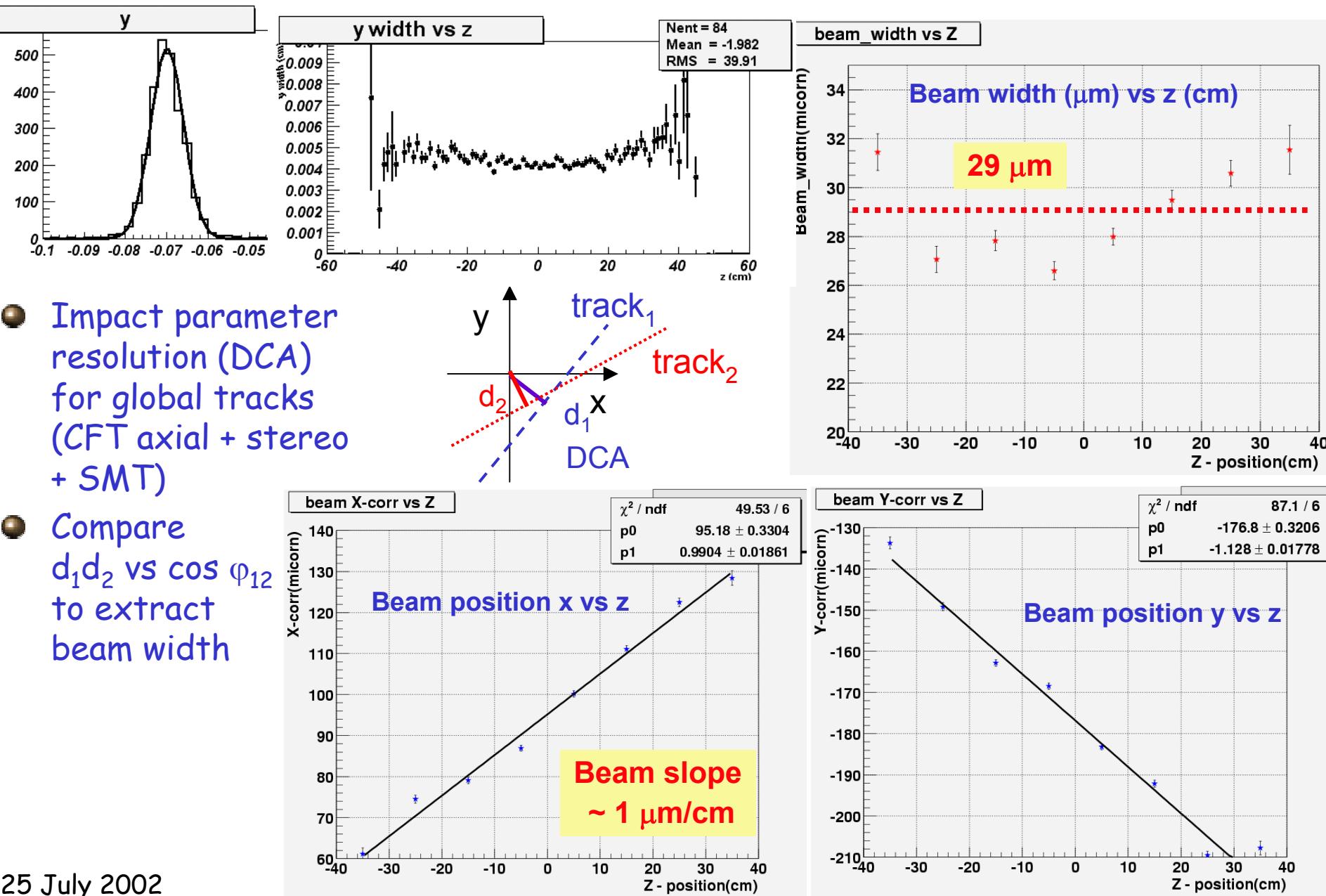


Tracking Performance

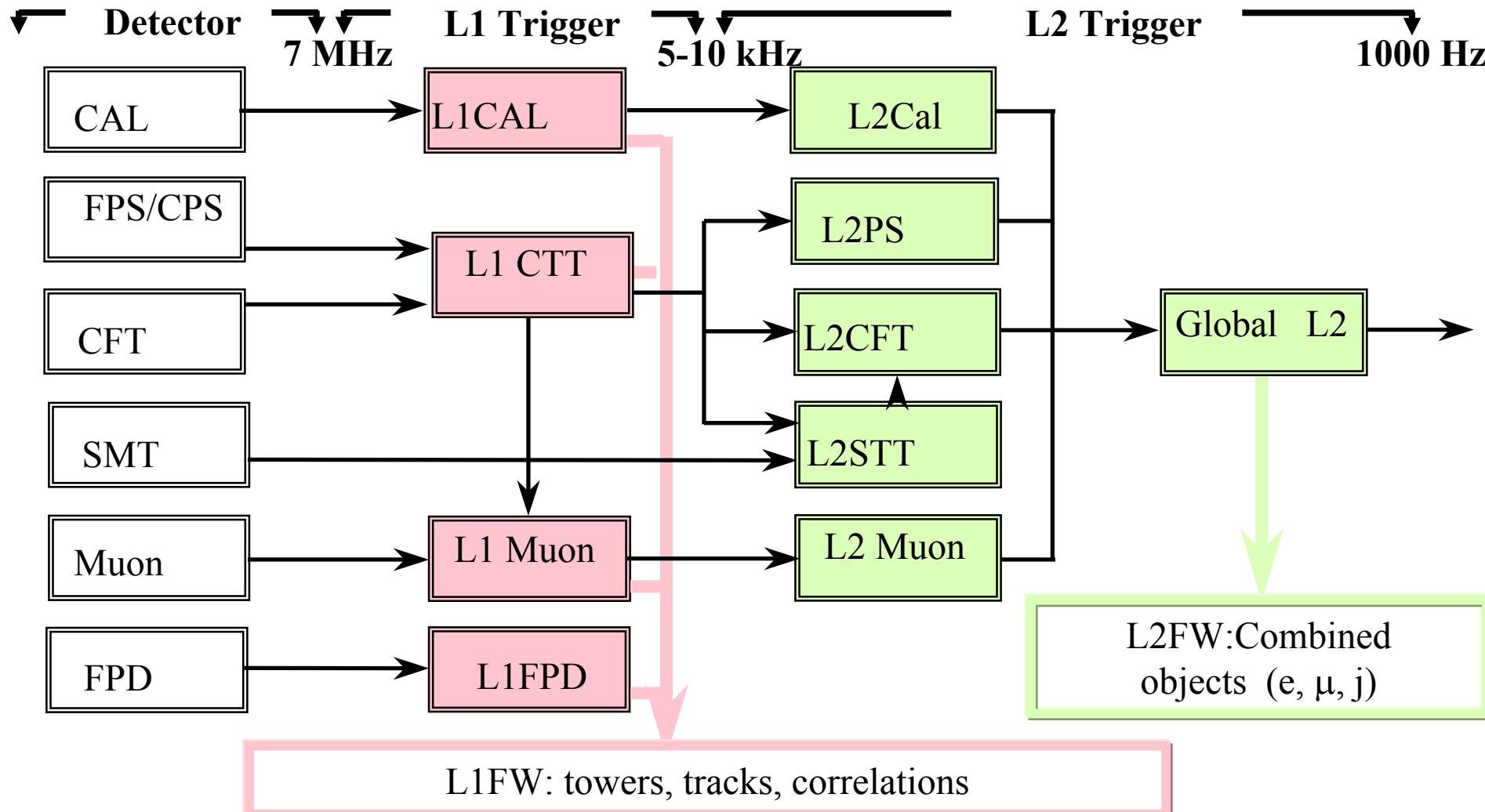
- p_T dependent impact parameter resolution at vertex is $\approx 100 \mu\text{m}$ using SMT only tracks and improves to $\approx 48 \mu\text{m}$ when CFT data is combined with SMT data--and is expected to improve further as studies progress



Beam Position and Alignment

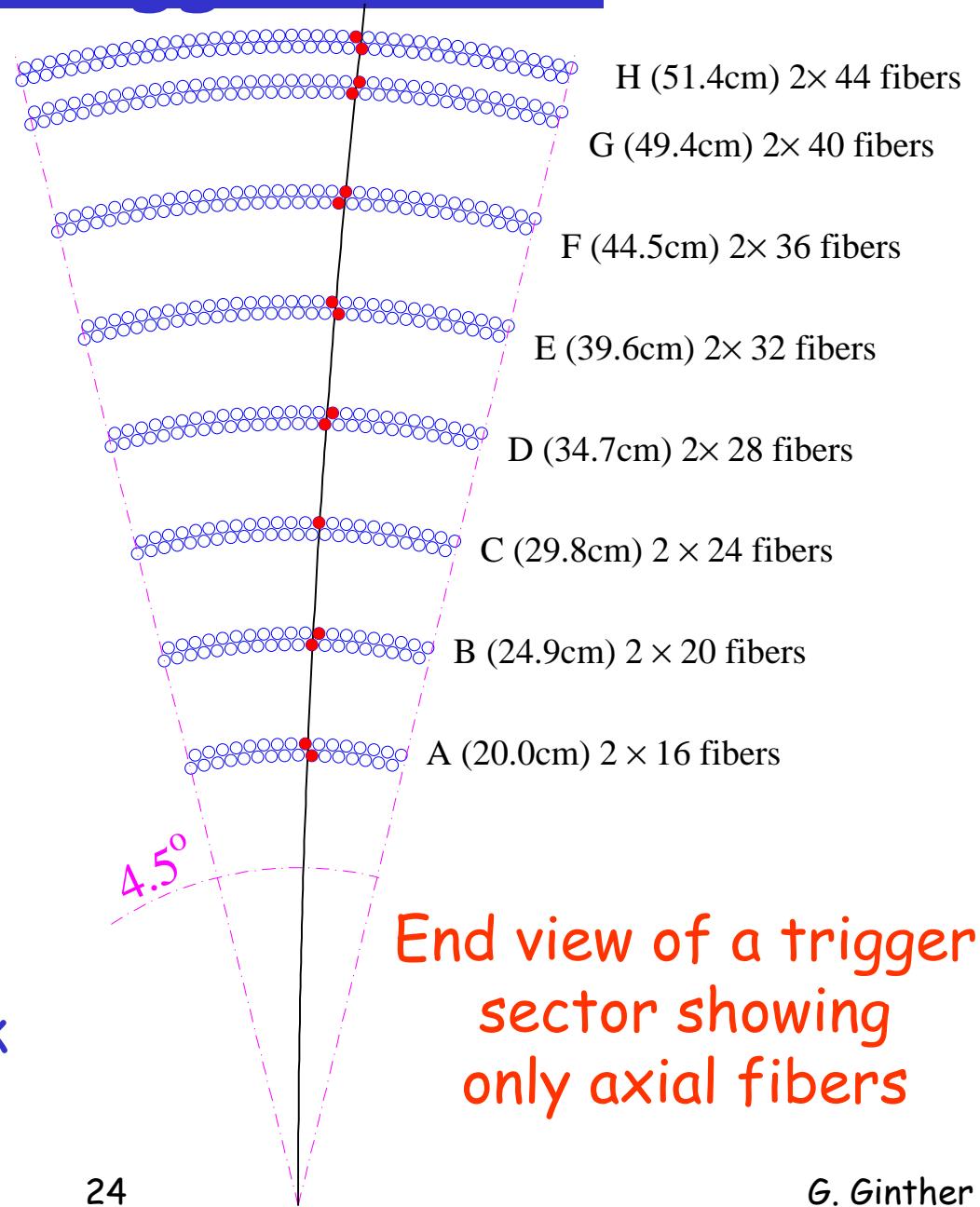


DØ Trigger System



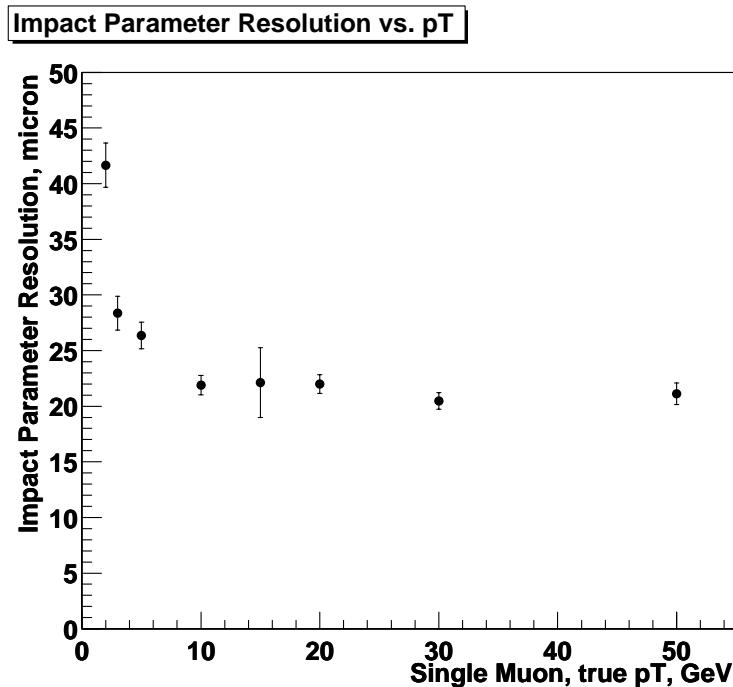
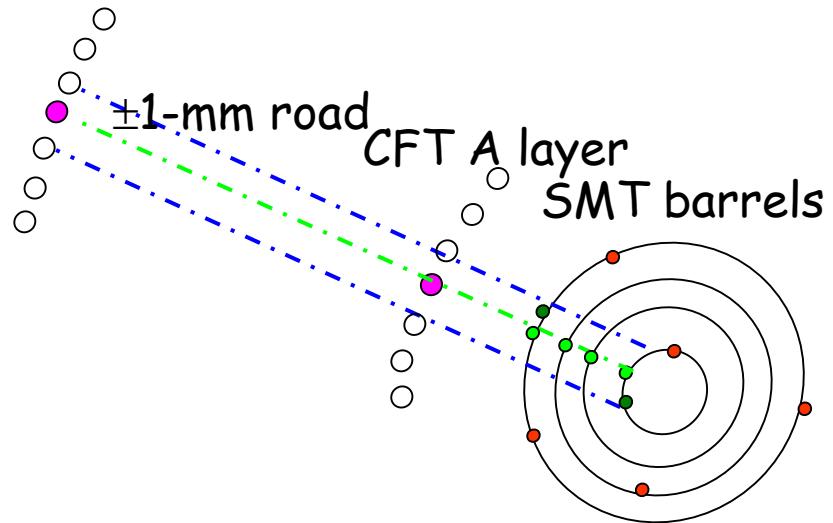
Central Track Trigger (CTT)

- Counts track candidates identified in axial view of CFT by looking for hits in all 8 axial layers within predetermined roads above four Pt thresholds (1.5, 3, 5, and 10 GeV/c)
- Combines tracking and preshower information to identify electron and photon candidates
- Generates track lists allowing other trigger systems to perform track matching



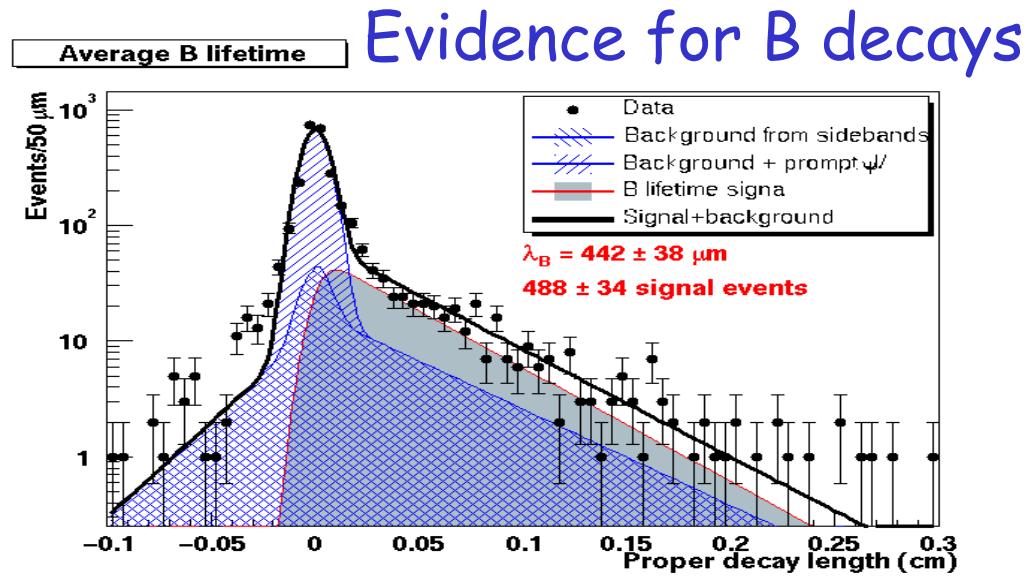
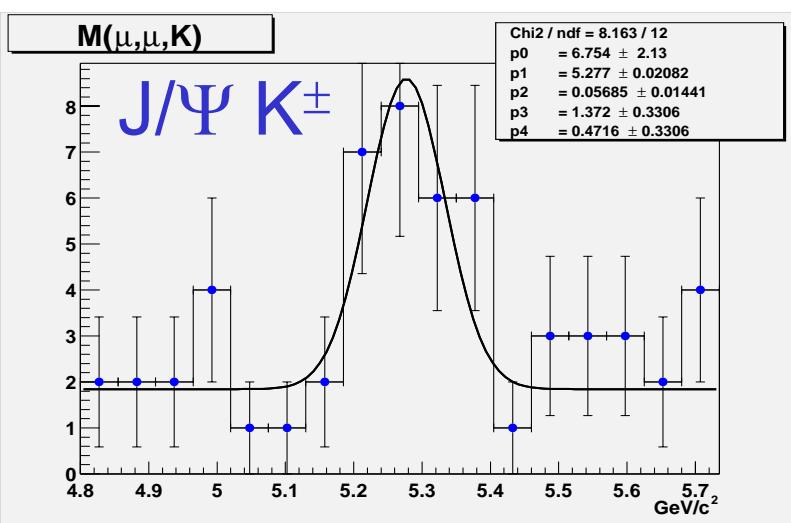
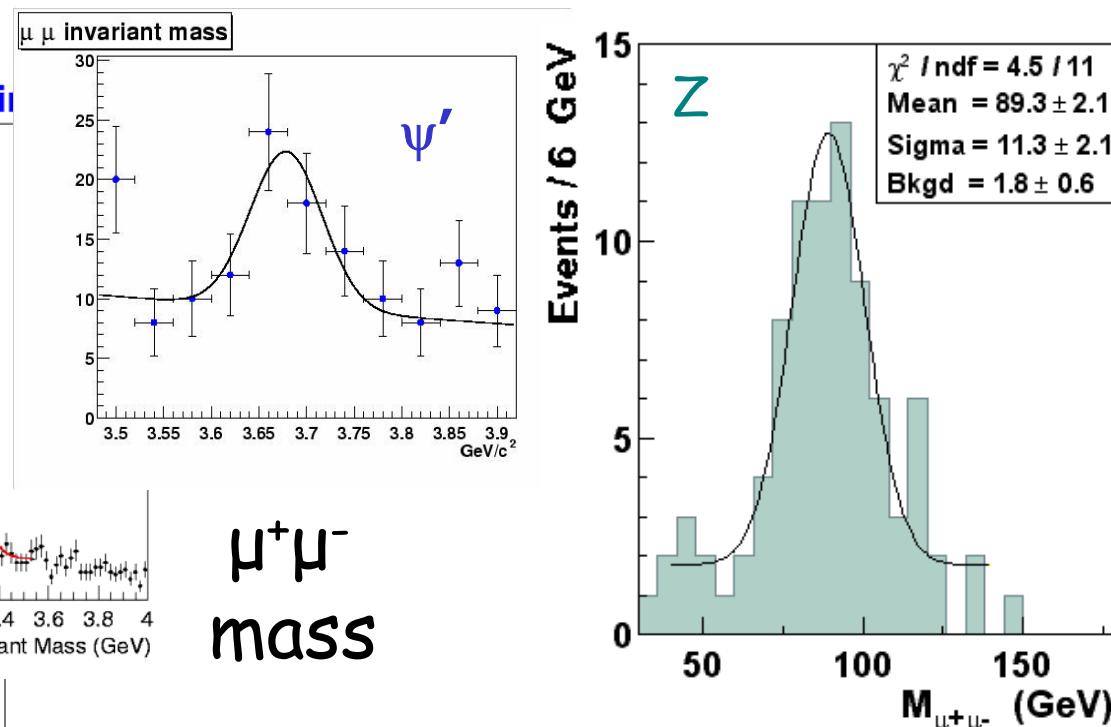
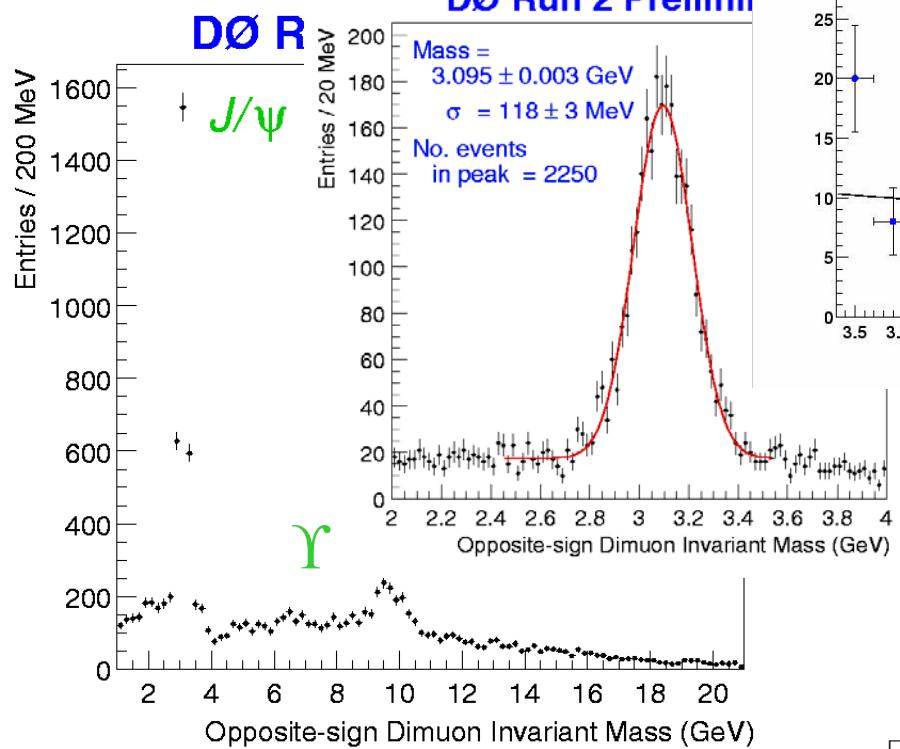
Silicon Track Trigger

- Combines inputs from CFT and SMT at Level 2 to select events
- Axial clusters matched to ± 1 mm wide roads around each CFT axial track via precomputed look up table



- Track fitting in Digital Signal Processors
- Prototypes of all boards in hand
- Hardware design complete and production in progress
- Firmware and integration tests ongoing

Physics Signals



DØ

The work of many
people including
some shown here ⇒

Thanks to all of
them!



The DØ Tracking System for Run II

- The Silicon Microstrip and Central Fiber Tracking systems are key components of the DØ Upgrade
 - Tracking detectors designed to have good impact parameter resolution over wide range of n
 - Readout system is generally stable and well behaved
 - Detectors are performing well
 - ≈95% of the SMT channels are available for readout
 - > 98% of the CFT channels are currently readout
 - Optimization and tracking refinements continue
 - CFT based triggering is currently being commissioned
 - Silicon Track Trigger hardware and firmware developing
 - Accumulation of data is in progress
 - Physics results are coming in

Additional Related Information

- Silicon detector upgrades for TeV Run II B
Mark Kruse later in this session
- For an overview of the DØ detector for Run II
Levan Babukhadia in session RD-2 later today
- For a summary of recent results from DØ
Meena Narain in Monday morning plenary session

Multiple Interactions

